GEM®STAT

COMPREHENSIVE SERVICE MANUAL

Mallinckrodt Sensor Systems, Inc
Ann Arbor, Michigan
48108-3248 U.S.A.
1 (800) 262-3654 or
313-973-7000

MALLINCKROD
Sensor Syste

GEM® Stat

PORTABLE BLOOD GAS, ELECTROLYTE, AND HEMATOCRIT ANALYZER

COMPREHENSIVE SERVICE MANUAL

Mallinckrodt Sensor Systems
1590 Eisenhower Place
Ann Arbor, MI 48108 USA
(800) 262-3654
(313) 973-7000

WARNING
IF SYSTEM IS OPERATED AT A TEMPERATURE
ABOVE 95°F (35°C) OR BELOW 60°F (15°C),
ACCURACY IS NOT GUARANTEED.
350140A

May 1993
Part No. 350138B

** IMPORTANT NOTICE **

Which Model GEM Stat do you own?

This manual contains service information for two different GEM Stat Models, a 120V, 60 Hz instrument, and a 120/230V, 50/60 Hz (Dual Voltage) instrument.

If you have the 120V, 60 Hz Instrument, the entire manual EXCEPT Appendix 6 is applicable. Please ignore Appendix 6.

If you have the Dual Voltage Instrument, you must substitute some of the pages in this manual with the appropriate pages that are in Appendix 6. Please refer to Appendix 6 now for instructions.

SCOPE

This manual provides detailed GEM Stat operating and servicing information for qualified technicians. Operators can also refer to the "*GEM Stat Operators Manual*".

- ***Chapter 1, Introduction***. Explains the purpose, application and general specifications.
- ***Chapter 2, Installation and Preparation***. Discusses storage requirements, unpacking, installation, startup and optional custom setup procedures.
- ***Chapter 3, Operation*** . Provides step by step instructions for normal operation including quality control procedures and an explanation of its special features.
- ***Chapter 4, Theory of Operation.*** Provides detailed information relative to the internal operation of the various systems. Includes block diagram and detailed descriptions by major component and functional systems.
- ***Chapter 5, Trouble-Shooting.*** Outlines procedures for trouble-shooting. Explains diagnostic messages and recommends appropriate service procedures.
- ***Chapter 6, System Checkout.*** Provides procedures to check the performance of the various systems.
- ***Chapter 7, Mechanical Disassembly.*** Provides detailed disassembly and reassembly instructions. Contains explosion views of all major subassemblies and complete parts list.
- ***Chapter 8, Electrical Circuits.*** Provides detailed electronic description of the major electrical systems operation. Contains schematics, wiring diagrams, printed circuit board layout drawings followed by an electronic component lists.
- ***Chapter 9, Cleaning.*** Provides instructions for cleaning blood from the instrument and debris in the fan filter.
- ***Appendix 1. Display Messages.*** Complete list of display messages that may appear on the Alphanumeric display with an explanation of what they mean.
- ***Appendix 2. Transmission Reports.*** Provides numerous examples transmission of reports via. RS232 port.
- ***Appendix 3. RS232 Communication Specifications.*** Explains RS232 connector pin-out information and communication parameters via RS232 port.
- ***Appendix 4. Electromechanical Specifications.*** Lists electromechanical specifications for major components and systems.
- ***Appendix 5. Printouts.*** Provides numerous examples of printouts during normal operation and shows how they are affected by optional setup items and sensor faults.
- ***Appendix 6. Dual Voltage Substitute pages.*** Substitute these pages for the appropriate pages as listed on page one of the manual IF you are using the 115/230V, 50/60 Hz instrument. See "Important Notice" in front of manual.

PROPRIETARY MATERIAL

Information and descriptions contained herein are the property of Mallinckrodt Sensor Systems. Such information and descriptions may not be copied or reproduced by any means, disseminated or distributed without prior written permission of Mallinckrodt Sensor Systems.

TABLE OF CONTENTS

CHAPTER 1; INTRODUCTION

1.1 PRODUCT DESCRIPTION 1
1.2 OPERATION SUMMARY 1
1.3 EQUIPMENT SUPPLIED WITH EACH GEM STAT INSTRUMENT 1
1.4 EQUIPMENT REQUIRED FOR OPERATION, BUT PURCHASED SEPARATELY 2
1.5 OPTIONAL ITEMS 2
1.6 DESCRIPTION OF THE GEM STAT COMPONENTS 2
  GEM Stat (Product Number 4300, 4400, 4500, 4600, 4700) 2
  GEM Statpak (Product Number 4301) 2
  GEM Sampler (Product Number 4305) 2
  GEM Check (Product Number 2306) 3
  GEM crit Check (Product Number 2309) 3
  Reusable Case (Product Number 84009) 3
1.7 SPECIFICATIONS 3
  Applicable safety standards 3
  Environmental conditions for operation 4
  Environmental conditions for storage 4
  Physical specifications 4
  Power requirements 4
  Quality control solutions specifications 4
    GEM Check 4
    GEM crit Check 5
  Measured parameters 5
  Derived parameters 5
  Miscellaneous specifications 6

CHAPTER 2; INSTALLATION AND PREPARATION

2.1 STORAGE INSTRUCTIONS 1
2.2 UNPACKING INSTRUCTIONS 1
  Customers with the reusable carrying case 1
  Customers without reusable carrying case 1
2.3 INSPECTION OF COMPONENTS 2
2.4 INSTALLING THE GEM STAT 2
2.5 INSTRUMENT FRONT PANEL DISPLAYS AND KEYPAD FUNCTIONS 4
2.6 INSTALLING/CHANGING THE PRINTER PAPER 5
2.7 GEM STAT POWER UP INSTRUCTIONS 5
2.8 INSERTING A NEW CARTRIDGE 6
2.9 GEM STAT WARM-UP/HYDRATION MODE 7
2.10 CUSTOMIZING THE SYSTEM, "HIDDEN" KEY FUNCTIONS 8
  How to change the hidden key status 8
  Mandatory quality control 8

Mandatory ID........8
Date format........8
Counts........9
Units of measurement for blood gas partial pressures........9
Sample labeling........9
Analytes (Gas/Electrolyte/Hct)........9
Cal Stats........9

CHAPTER 3; OPERATING INSTRUCTIONS

3.1 OPERATION SUMMARY........1
Ready mode........1
Standby mode........1
QC mode........1
3.2 HOW TO PROCESS A BLOOD SAMPLE........2
1. Collect the blood........2
2. Enter patient and operator identification numbers........2
3. Aspirate the sample........3
4. Interpret the printout:........4
Sample printouts with missing values........4
Derived parameters........5
5. Normal physiological blood ranges........5
3.3 OPERATOR PERFORMANCE CHECKS........6
Calibration........6
Description of calibration failure detection........7
Correcting a calibration failure........7
Reasons to Initiate a 2-point calibration........8
How to initiate a 2-point calibration:........8
Quality Control (QC)........8
How to analyze a QC solution........10
3.4 RECORD KEEPING AND REPRINTING:........11
Printing duplicate records........11
To reprint a copy of the last sample analysis........11
To reprint QC records, blood analyses, or calibration records........12
3.5 MISCELLANEOUS FUNCTIONS........12
Paper feed........12
Cartridge status........12
How to print the cartridge status........13
Temperature correction........13
How to temperature correct a blood sample........14
Standby mode........14
How to enter standby........15
How to exit standby........15
Date and time........16
How to change the date and/or time........16
3.6 POWER INTERRUPTION........16
3.7 CARTRIDGE REMOVAL........17

CHAPTER 4; THEORY OF OPERATION

- 4.1 OVERVIEW 1
- 4.2 MAJOR COMPONENT DESCRIPTION 1
  - GEM Statpak cartridge 1
  - GEM Stat instrument 4
    - Buffer amplifier and heater block assembly 4
    - Analog-Digital circuit board assembly 5
    - Thermal printer 5
    - Display assembly 6
    - Keypads 6
    - Power Supply assembly 6
    - Pump motor 6
    - Valve motor 6
    - Door Lock and cartridge lock-out solenoids 6
    - RS-232 port 7
    - Software operating system 7
    - Interface switches 7
- 4.3 DESCRIPTION OF MAJOR GEM STAT SYSTEMS 7
  - Sensing systems 7
    - Hematocrit 7
    - Calcium, Sodium, Potassium, Carbon Dioxide and pH 7
    - Oxygen 8
  - Calibration system 8
  - Isolated analog power system 9
  - Heater Block thermal control Loop 9
  - Processing and Internal communication system 9
  - Fluid system 9
    - Pump System 10
    - Valve Actuator System 10

CHAPTER 5; TROUBLE-SHOOTING

- 5.1 TROUBLE-SHOOTING SUMMARY 1
- 5.2 INOPERATIVE INSTRUMENT 2
  - Instrument inoperative: no visible power 2
  - Instrument inoperative: display contains scattered LED segments 3
  - Alpha-Numeric display stays at "INSERT CART" 3
- 5.3 PRINTER PROBLEMS/FAILURE 5
  - Printer inoperative - no printing or paper does not advance 5
  - Paper will not feed out although it sounds like its working 6
  - Printer feeds paper, but does not print. 7
- 5.4 KEYBOARD PROBLEMS/FAILURE 7
- 5.5 HEATER BLOCK FAILURE 7
- 5.6 ALPHA-NUMERIC DISPLAY ERROR MESSAGES: 9
  - CRC failed 9
  - RAM failed message 9
  - Sample error 9
  - Valve failed (Also prints on print out if paper is installed) 9

5.7 SAMPLING PROBLEMS 10
  Sample will not aspirate 10
  Cartridge values do not compare with the lab. 10
  Display reads, "OP000000000" and sample won't aspirate 11
  Display reads, "PA000000000" and sample won't aspirate 11
5.8 CALIBRATION PROBLEMS OR FAILURES 11
  Multiple parameter failures with multiple cartridges 11
5.9 QC PROBLEMS OR FAILURES 12
  QC Values are not displayed on the instrument. 12
  QC Printout Values are Blank followed by a question mark 12
  PO2 failed QC (other values are within range). 12
  Multiple parameter values failed QC. 12
  QC Values are displayed and reported on patient sample printout 12
  Display reads, "BAD LOT NUM" 13
  Display reads, "MUST DO QC" 13
5.10 MISCELLANEOUS PROBLEMS 13
  Instrument will not go into Standby 13
  Display reads, "NO GOOD DATA" 13
  Display reads, "PLEASE WAIT" 13
  Display reads, "RECOVERING" 13
  Display reads, "REMOVE CART" (remove cartridge) 13

CHAPTER 6; BASIC SYSTEM OPERATION TEST

6.1 PURPOSE 1
6.2 EQUIPMENT REQUIRED 1
6.3 BASIC OPERATION TESTS 1
  Power-up test. 1
  Real-Time clock test. 2
  Printer test. 2
  Clock battery test 2
  Power fail test 2
  Functional diagnostic Tests 3
    1. Keyboard Test. 3
    2. Display Test. 3
    3. Cartridge Valve Actuator Test. 4
    4. Pump Motor Speed Test 4
    5. Printer Test. 4
    6. Thermal Test. 4
    7. Simulator Cartridge Test 5
  Diagnostic keypad definitions 8
  Test form 9

CHAPTER 7; MECHANICAL DISASSEMBLY

7.1 OVERVIEW 1
7.2 TOOLS REQUIRED FOR DISASSEMBLY 2
7.3 GENERAL DISASSEMBLY PROCEDURE 2
7.4 MAJOR SUBASSEMBLY DIAGRAMS 10

7.5 COMPLETE GEM STAT PARTS LIST 17

CHAPTER 8; ELECTRICAL CIRCUITS

8.1 POWER SUPPLY 1
  Isolated power supply 1
  Main power supply 1
    DC Power Supply 1
    Power fail detect circuit 4
    Motor Control Circuitry on the Power Supply Board 6
    Signal Interconnection 6
  Parts list for power supply board 9
8.2 HEATER BLOCK AND TEMPERATURE CONTROL 11
8.3 ANALOG-DIGITAL (A/D) CIRCUIT BOARD 11
  Recent changes to A/D board 11
  Unused circuitry on the P.C. board 12
  Electrode differential amplifiers 12
  Analog multiplexer 13
  Low pass filter 13
  Voltage to frequency converter 14
  Microprocessor circuitry 14
    Central processing unit 14
    Read-Only memory (ROM) 14
    Random-access memory (RAM) 15
    RS-232 port 15
    Address bus decoder 15
    Motor control signals 15
    Printer interface 15
    Display control 16
    Light emitting diode (LED) control 16
    Keyboard interface 16
    System Status Signals 16
    System real time calendar clock 16
    Opto-Isolator and solid state relay drive 16
  Parts List for A/D board 22
8.4 DISPLAY CIRCUIT DESCRIPTION 26
  Device Select Decoder 26
  Numerical Displays and Display Drivers 26
  Intelligent Alphanumeric Display 26
  LED Driver 26
  Parts list for display board assembly 29
8.5 PRINTER ELECTRONICS DESCRIPTION 29
8.6 DOOR LOCK, SOLENOIDS (K1 & K2), SOLENOID DRIVER BOARD 29
  Parts list for solenoid driver board 31
8.7 INNER WALL ELECTRONIC CIRCUITRY 32
8.8 REAR PANEL ELECTRICAL CIRCUITRY 34

CHAPTER 9; CLEANING PROCEDURES

9.1 BLOOD CLEANING PROCEDURES 1
  Materials required for cleaning blood.......... 1
  Method for Cleaning up Blood 1
9.2 CLEANING FAN FILTER 2

APPENDIX 1; DISPLAY MESSAGES

APPENDIX 2; FORMATS OF TRANSMISSION REPORTS

REPORT TRANSMISSION DESCRIPTION 1
OPERATING MODE SELECTIONS 2
  Gases only, electrolytes only, or both modes. 2
  Sample labeling. 2
  Temperature correction. 2
  Calibration data reporting. 2
EXAMPLES OF REPORT TRANSMISSIONS : 3
  Sample report (electrolytes only) 3
  Sample report (Gases only) 3
  Sample report (Temperature Corrected) 4
  Sample report (labeling enabled) 5
  Sample report (longest) 5
  QC report (electrolytes only) 6
  QC report (gases and electrolytes) 6
  1-Point CAL report (Electrolytes Only) 6
  2-Point CAL report (Gases and Electrolytes with CAL STAT enabled) 7
  Last CAL report (electrolytes only) 7
  Sample report (after several electrodes had CAL failures) 8
  Sample report (Flawed sample test) 8
  Raw count value report 9
  Report after power failure 9
  Status report (all electrodes operational) 10
  Status report (after several calibration failures) 10
  2-Point CAL completion message (no electrode failures, CAL STAT disabled) 11
  2-Point CAL completion message (electrode slope errors detected) 11

APPENDIX 3; RS-232 COMMUNICATIONS SPECIFICATION

GENERAL DESCRIPTION 1
CONNECTOR AND SIGNAL DESCRIPTION 1
BAUD RATE, FORMAT, AND HANDSHAKING 1
DATA TRANSMISSION PROTOCOL 2

APPENDIX 4; ELECTROMECHANICAL SPECIFICATIONS

POWER SUPPLIES 1

ELECTRODE BUFFER AMPLIFIERS (REF, PH, CA++, NA+, K+ AND CO_2 ELECTRODES) 1
OXYGEN CHANNEL 1
HEMATOCRIT CHANNEL 1
DIFFERENTIAL GAIN STAGES, PH, CA++, NA+, K+, CO_2 1
HEATER BLOCK THERMOSETTING 2
ANALOG-TO-DIGITAL CONVERSION 2
CARTRIDGE VALVE STEPPER MOTOR 2
PUMP MOTOR/ROTOR SYSTEM 2
MICROPROCESSOR TIME BASE 2
RS232 PORT 2
BATTERY BACKED MEMORY 2
REAL TIME CLOCK 3
PRINTER 3
ISOLATION AND LEAKAGE CURRENTS 3
    Dielectric withstand voltage 3
    Maximum leakage currents 3
    Physical spacing 3

APPENDIX 5; PRINTOUTS

GENERAL INFORMATION 1
PRINTOUT OPTIONS ACCESSED FROM HIDDEN FUNCTION MENU 2
    Gases only, Electrolytes only, or both. 2
    Sample labeling. 2
    Calibration data reporting. 2
MISCELLANEOUS FUNCTIONS' AFFECT ON PRINTOUTS 4
    DATE and TIME 4
    STANDBY mode 4
    Temperature correction. 4
    Cartridge STATUS report 5
RECORD KEEPING AND REPRINTS 5

APPENDIX 6; PAGES TO SUBSTITUTE IF USING THE 110/220 V, 50/60 HZ MODEL.

IMPORTANT NOTICE; HOW TO USE THIS APPENDIX 1
INNER PANEL ASSEMBLY 2
REAR PANEL ASSEMBLY 3
COMPLETE GEM STAT PARTS LIST 4
POWER SUPPLY 8
POWER SUPPLY ASSEMBLY SCHEMATIC 10
WIRING DIAGRAM 11
SOLENOID DRIVER BOARD PARTS LIST 12
SOLENOID DRIVER BOARD SCHEMATIC 13
INNER WALL WIRING DIAGRAM 14
INNER WALL SCHEMATIC 15
REAR PANEL WIRING DIAGRAM 16
REAR PANEL SCHEMATIC 17

FIGURES

Fig. 2-1, Front Panel Displays and Keypads 2-3
Fig. 2-2, Adding Printer Paper 2-5
Fig. 3-1, Make sure the GEM Sampler stop line is flush with the cartridge 3-3
Fig. 3-2, Immerse the Sampler in blood then press the START keypad 3-3
Fig. 3-3, Cancelled Sample Message 3-4
Fig. 3-4, Normal Sample printout 3-4
Fig. 3-5, Sample printout with O_2 Sensor problem 3-4
Fig. 3-6, 2-Point CAL Message 3-7
Fig. 3-7, 2-Point CAL Stat Report 3-7
Fig. 3-8, Location of Lot No. on QC ampule 3-10
Fig. 3-9, Aspirating solution from QC ampule 3-10
Fig. 3-10, Status Report 3-13
Fig. 3-11, Temperature Corrected printout 3-14
Fig. 4-1, GEM Stat System, Simple Block Diagram 4-3
Fig. 4-2, GEM Stat, major components (1 of 2) 4-4
Fig. 4-2, GEM Stat, major components (2 of 2) 4-5
Fig. 5-1, Location of switch SW1 5-4
Fig. 5-2, Location of switch SW3 5-5
Fig. 6-1, Printout, printer test 6-2
Fig. 6-2, Power fail test printout 6-3
Fig. 6-3, Printout diagnostic Print Test 6-4
Fig. 6-4, Simulated auto sample test 6-6
Fig. 6-5, Simulated sample limits 6-7
Fig. 6-6, Test result form 6-9
Fig. 7-1, Removing the Cover Assembly 7-2
Fig. 7-2, Removing the A/D board Insulator 7-3
Fig. 7-3, Removing the A/D board 7-4
Fig. 7-4, Disconnecting the Printer power cable 7-5
Fig. 7-5, Removing the Printer 7-5
Fig. 7-6, Removing the Front and Inner Panel 7-6
Fig. 7-7, Disconnecting Main Transformer cable and Wire Harness from Power Supply 7-7
Fig. 7-8, Removing the Power Supply 7-7
Fig. 7-9, Removing the Rear Panel 7-8
Fig. 7-10, Removing the Main Transformer 7-9
Fig. 7-11, Inner Panel Assembly 7-11
Fig. 7-12, Front Panel Assembly 7-12
Fig. 7-13, Rear Panel Assembly 7-13
Fig. 7-14, Cover Assembly 7-14
Fig. 7-15, Cartridge Door Assembly 7-15
Fig. 7-16, Printer Assembly 7-16
Fig. 8-1, Detailed Electrical Block Diagram 8-2
Fig. 8-2, Power Supply Assembly (MSS # 500018) 8-7
Fig. 8-3, Power Supply Assembly (MSS # 500018) Schematic 8-8
Fig. 8-4, A/D Board (MSS # 480006) 8-17

Fig. 8-5, A/D Board Schematic (MSS # 480006) (1 of 3) 8-18
Fig. 8-6 A/D Board (MSS # 480006) Schematic (2 of 3) 8-19
Fig. 8-7, A/D Board (MSS # 480006) Schematic (3 of 3) 8-20
Fig. 8-8, Main Harness Schematic 8-21
Fig. 8-9, Display Board (MSS # 500023) 8-27
Fig. 8-10, Display Board (MSS # 500023) Schematic 8-28
Fig. 8-11, SW1, SW3 and K1 Wiring Diagram 8-30
Fig. 8-12, Solenoid Driver Board PCB Layout 8-31
Fig. 8-13, Solenoid Driver Board Schematic 8-31
Fig. 8-14, Inner Wall Wiring Diagram 8-32
Fig. 8-15, Inner Wall Schematic 8-33
Fig. 8-16, Rear Panel Wiring Diagram 8-34
Fig. 8-17, Rear Panel Schematic 8-35
Fig. A5-1, Sample Report A5-1
Fig. A5-2, QC Reports A5-2
Fig. A5-3, 2-Point CAL Reports (Cal Stat ON) A5-3
Fig. A5-4, 2-Point CAL Reports (Cal Stat OFF) A5-3
Fig. A5-5, Temperature Corrected Report A5-4
Fig. A5-6, Status Reports A5-5

TABLES

Table 1-1, Physical Specifications, GEM Stat, GEM Statpak 1-4
Table 1-2, GEM Stat Model List and Power Requirements 1-4
Table 1-3, Measured Parameters 1-5
Table 1-4, Derived Parameters 1-5
Table 2-1, "Hidden Key" Defaults 2-8
Table 3-1, Measured Parameters used to calculate Derived parameters 3-5
Table 3-2, Normal expected values for whole blood 3-5
Table 3-3, Reprint Options 3-11
Table 4-1, CAL-A and CAL-B "preset" values 4-9
Table 6-1, Diagnostic Keypad functions 6-8

CHAPTER 1; INTRODUCTION

1.1 PRODUCT DESCRIPTION

The GEM Stat system is a portable, self-contained blood gas, electrolyte, and hematocrit analyzer. It aspirates blood from a syringe via a piece of tubing---the GEM Sampler. Calibration fluids, a waste bag, and electrodes are housed in a disposable cartridge. The cartridge is inserted into the instrument and lasts for three days, or 50 analyses, whichever comes first.

The system performs automatic calibrations and self-checks. pH, Carbon dioxide partial pressure (PCO_2), Oxygen partial pressure (PO_2), Sodium (Na+), Potassium (K+), Ionized Calcium (iCa++), and Hematocrit (Hct) are measured directly. Bicarbonate (HCO_3), Total Carbon-dioxide (TCO_2), Base excess (BE), and Oxygen Saturation (SAT) are calculated from the measured parameters.

1.2 OPERATION SUMMARY

1. Insert the disposable GEM Statpak cartridge into the instrument to initiate the automatic "warm-up". The process is as simple as loading a video cassette. The system will let you know when it is ready. (Total time for this warm-up period is about 45 minutes)
2. Insert a GEM Sampler into the end of the cartridge. Present a heparinized 0.5 cc whole blood sample to the instrument, then push the SAMPLE button.
3. The system will automatically aspirate the sample, process the results, then display and print them in less than two minutes.

   Leave the cartridge inserted for as long as 72 hours. During that time, up to 50 blood samples can be analyzed, each yielding all eleven parameters. Status updates show remaining time and sample capacity, making it convenient to use GEM Stat throughout shift changes, 24 hours a day. When the cartridge is depleted, simply throw it away and insert a new cartridge. Since all blood and used solutions are collected in the sealed cartridge, no clean-up is required.

1.3 EQUIPMENT SUPPLIED WITH EACH GEM STAT INSTRUMENT

Item	Quantity	Part Number
GEM Stat Instrument	1 ea.	4X00 *
Operators Manual	1 ea.	380019
Printer Paper	2 rolls	2308

* Refer Table 1-2 for complete GEM Stat model number list.

1.4 EQUIPMENT REQUIRED FOR OPERATION BUT PURCHASED SEPARATELY

Item	Part Number
GEM Statpak	4301
GEM Check	2306
GEM Sampler	4305
GEM crit Check	2309

Heparinized syringe or other blood collection device.

1.5 OPTIONAL ITEMS

Item	Part Number
Comprehensive Service Manual .	380025
Carrying Case	840009
Quality Assurance Manual	380023

1.6 DESCRIPTION OF THE GEM STAT COMPONENTS

GEM Stat (Product Number 4300, 4400, 4500, 4600, 4700)

Electronic instrument that analyzes blood gases, electrolytes, and hematocrit.

- Measures pH, PCO_2, PO_2, Na+, K+, iCa++ and Hct.
- Derives HCO_3, TCO_2, BE, and O_2SAT.
- Hard copy printout provided with each analysis for complete sample identification.
- Front panel display provides numeric readout for each measured analyte.
- Alphanumeric display provides instrument status information, keyboard prompts, etc.
- Keyboard allows command and data entry.
- Temperature Correction capability.

GEM Statpak (Product Number 4301)

Disposable cartridge containing electrochemical sensors, calibrating and flush solutions, and waste container.

- Disposable
- Provides up to 50 tests or 24 hours of sampling capability.
- Self-contained cartridge includes sensors, calibration and flush solutions, and waste container.
- 48-hour standby period extends total cartridge use life to 72 hours.

GEM Sampler (Product Number 4305)

Disposable attachment that allows introduction of blood samples to the GEM Statpak cartridge.

GEM Check (Product Number 2306)

Aqueous solutions containing known values of gases and electrolytes that permit system quality control checks of pH, PCO_2, PO_2, Na+, K+, and iCa++.

- Low, Normal, and High values provided in each package.
- Designed to comply with laboratory QC requirements.

GEM crit Check (Product Number 2309)

Aqueous solutions simulating known values of hematocrit that permit system quality control checks of Hct.

- Low and Normal values provided in each package.
- Designed to comply with laboratory QC requirements.

Reusable Case (Product Number 84009)

An impact resistant case as defined by MIL-D-42048, used to transport and/or store the GEM Stat instrument.

1.7 SPECIFICATIONS

Following are electromechanical specifications for the GEM Stat Instrument. Performance specifications of the GEM Statpak Cartridge are not included. Aspects such as accuracy and analyses repeatability, and dynamic range of blood chemistry measurements should be determined during clinical use with the entire GEM Stat System.

CAUTION:

Mallinckrodt Sensor Systems warrants the GEM Stat System to perform within the specification limits stated in this manual. It is the responsibility of the user to review the specifications and determine the suitability of the system for any particular application.

Applicable safety standards

- UL-544 Standard for Medical and Dental Equipment
- IEC-601-1.
- The European model GEM Stat system is approved by, TUV Nordeutsland.

Environmental conditions for operation

- Temperature Range: 60°F to 95°F (15°C to 35°C)
- Relative Humidity Range: 5% to 90% (non-condensing)

Environmental conditions for storage

- Temperature Range: -10°F to 120° F (-23°C to 49°C)
- Relative Humidity Range: 5% to 95% (non-condensing)

Physical specifications

Characteristic	GEM Stat	GEM Statpak
Width (in/cm)	92.12 / 23.2	3 / 5.1
Depth (in/cm)	18.25 / 46.4	8.06 / 20.5
Height (in/cm)	8.38 / 21.3	5 / 12.7
Weight (lb /kg)	27.7 / 12.6	1.6 / 0.7

Table 1-1, Physical specifications, GEM Stat, GEM Statpak

Power requirements

(Power Consumption: 102 Watts nominal)

GEM Stat Model #	Intended Users	Power Source (-15%+10%)
4300*	U.S.A., Military	115/230 VAC 50/60 Hz
4400	Japan	100 VAC 60 Hz
4500	Japan	100 VAC 50 Hz
4600	Europe	220 VAC 50 Hz
4700	U.K.	240 VAC 50 Hz

Table 1-2, GEM Stat Model list and Power Requirements

* User switchable. On all other units, operating frequency is determined at the factory and can only be altered by authorized service personnel.

Quality Control Solutions Specifications

GEM Check

Three levels per package, 10 ampules each level. Each ampule contains 3 ml of solution pre-analyzed for pH, PCO_2, PO_2, Na+, K+, and iCa++.

- Low Level: Lower than normal blood values
- Normal Level: Normal blood values
- High Level: Higher than normal blood values

GEM crit Check

Two levels per package, 15 ampules each level. Each ampule contains 3 ml of solution pre-analyzed for Hematocrit (Hct).

- Low Level: Hematocrit lower than normal blood value.
- Normal Level: Hematocrit at normal blood value.

Measured parameters

Analyte	Proper Name	Displayed Range	Resolution
pH	pH	6.80 to 7.80	0.01
PCO_2 (mmHg)	Carbon Dioxide partial pressure	5 to 99	1
PO_2 (mmHg)	Oxygen partial pressure	0 to 999	1
Na^+ (mmol/L)	Sodium Ion concentration	100 to 200	1
K^+ (mmol/L)	Potassium Ion concentration	0.1 to 9.9	0.1
iCa^{++} (mmol/L)	Ionized Calcium Ion concentration	0.1 to 5.0	0.1 (display), 0.01(printout)
Hct (%)	Hematocrit percentage	5 to 60	0.1

Table 1-3, Measured parameters

Note:
iCa++ is Calcium Ion Concentration.
Other laboratory instruments may measure other forms of Calcium.

Derived parameters

Analyte	Proper Name	Displayed Range	Resolution
HCO_3 (mmol/L)	Bicarbonate Ion concentration	3.0 to 60	0.1
TCO_2 (mmol/L)	Total Carbon Dioxide concentration	3.0 to 60	0.1
BE (mmol/L)	Base Excess concentration	-30 to +30	1
O_2 SAT (%)	Oxygen Saturation percent	30 to 99	1

Table 1-4, Derived parameters

Miscellaneous specifications

• Sample Volume:	0.5 ml
• Sample Requirement:	Whole blood with addition of approximately 25 USP units/ml Sodium or Lithium Heparin.
• Sampling Throughput:	Maximum 11 samples/hour
• Response Time:	110 sec. from sample introduction
• Measurement Methodologies:	PO_2 -- Polarographic pH, Na+, K+, iCa++, PCO_2 -- Potentiometric Hct -- Conductivity
• Automatic Calibration Frequencies:	Two-point calibration every 60 minutes. One-point calibration every 90 seconds.
• Temperature Control:	Electrode chamber maintained at 37°C, +/- 0.2°C.
• Time and Date:	Internal 24-hour calendar clock, battery powered.
• Product Safety:	UL Listed under UL-544, IEC 601.
• Data Output Port:	RS-232 (See Appendix 3)

Refer to Appendix 4, "Electromechanical Specifications" for specifications on GEM Stat components.

CHAPTER 2; INSTALLATION AND PREPARATION

2.1 STORAGE INSTRUCTIONS

These instructions apply to the instrument only, not to the disposable GEM Statpak reagent cartridge or quality control solutions.

Keep the instrument in its original packaging, with plastic around the instrument and desiccant packets within the plastic. In the original packaging, it can be stored outdoors within the following limits:

Temperature:	-10°F to +120°F (-23°C to +49°C).
Humidity:	5% - 95%
Altitude:	Unaffected by altitude

Use a waterproof covering to protect the packaged instrument from moisture. Minimize movement between high and low temperatures to prevent condensation.

No periodic adjustments or inspections are required if the instrument is within these temperature and humidity ranges.

Under these conditions the life of the GEM Stat is indefinite.

2.2 UNPACKING INSTRUCTIONS

Customers with the reusable carrying case
(Refer to the printed laminated panel on the inside cover of the reusable carrying case)

1. Open the top of the carton and remove the reusable carrying case.
2. Open the carrying case.
3. Remove the Service Manual, Operators Manual, detachable cord, and printer paper from the carrying case.
4. Remove the instrument from the carrying case.

Customers without reusable carrying case

1. Open the top of the carton.
2. Remove the Operators Manual, printer paper, and detachable line cord from the box.
3. Remove the instrument from the box. The protective foam end caps that surround the instrument will remain with the unit as it is pulled from the box.
4. Remove the foam end caps from the instrument.
5. Remove instrument from protective plastic bag.
6. Keep original packaging materials. Always repackage the instrument in the original materials when transporting the instrument.

2.3 INSPECTION OF COMPONENTS

Inspect packing case and instrument for external damage. All components should be clean and without blemishes. If damage has occurred, a claim must be filed with the delivering carrier within 10 days. Although the Mallinckrodt Sensor Systems Warranty does not cover damage due to shipping, our Customer Service Department or an Authorized Agent will assist you in determining the damages so that a proper claim may be filed.

If you feel service is necessary, contact Customer Service. If it is decided that a component should be repaired or replaced, you will be issued a Return Goods Authorization (RGA) number. Ship product to:

Mallinckrodt Sensor Systems
1590 Eisenhower Place
Ann Arbor, MI 48108
Phone: (800) 262-3654
or (313) 973-7000

2.4 INSTALLING THE GEM STAT

Install the GEM Stat by simply placing it in any convenient location. Attach the line cord to any grounded, properly wired outlet that meets the voltage rating stamped on the back panel of the instrument.

Place the GEM Stat on a level surface such as a cart, counter, or bench top during operation. Comfortable operation is on a counter 34" - 54" high (depending on whether you operate the unit while sitting or standing). The analyzer requires a space no larger than 15 inches wide by 20 inches deep by 12 inches high. Leave about 6 inches behind the instrument to reach the power switch and allow the fan to pull in cooling air. Both are located on the back of the instrument. It is advisable to leave space nearby for the disposable cartridges and quality control solutions.

Do not place next to heating or cooling devices.

Operating temperature range:	60^{O}F to 95^{O}F (15^{O}C to 35^{O}C).
Operating relative humidity range:	5% to 90% (non-condensing).

WARNING
In order to prevent electrical shock hazard to operator, this device must be connected to a properly wired grounded receptacle.

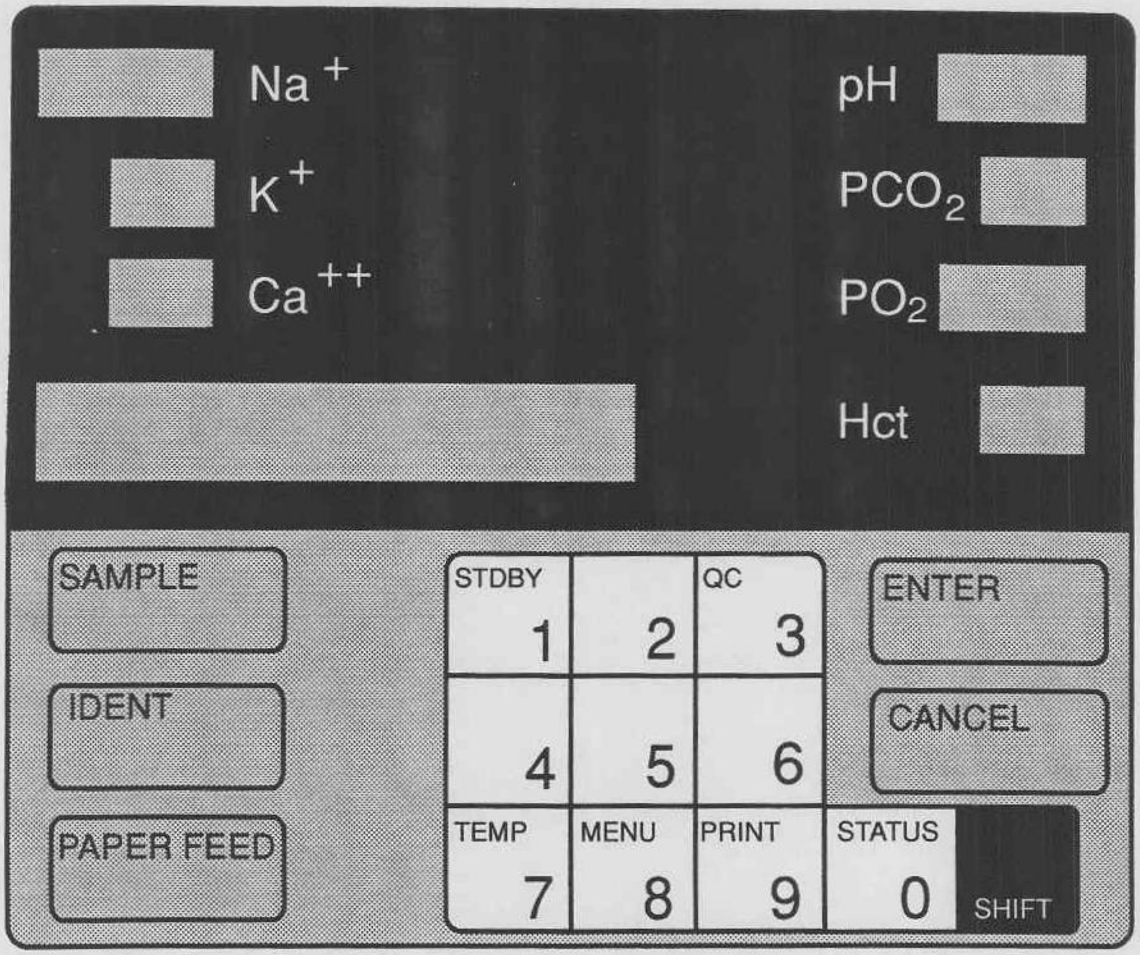

Na +
K +
Ca ++
pH
PCO2
PO2
Hct
SAMPLE
IDENT
PAPER FEED
STDBY 1
2
QC 3
4
5
6
TEMP 7
MENU 8
PRINT 9
STATUS 0
SHIFT
ENTER
CANCEL

Fig. 2-1; Front panel displays and keypads

2.5 INSTRUMENT FRONT PANEL DISPLAYS AND KEYPAD FUNCTIONS

Keypad / Display Name	Functional Description
Numeric Window Displays:	Displays values for each analyte
Na+, K+, Ca++, pH, PCO2 PO2, Hct.	
Alphanumeric Display	Shows GEM Stat status, messages and user supplied information.
Primary Keypads:	
Sample	Press to aspirate Sample or QC solution.
Identification	Press to enter Patient or Operator ID.
Paper Feed	Feeds paper. Used to start new roll.
Enter	Used to confirm selections and numbers.
Cancel	Aborts current function.
Numeric Keypads	Used to enter numeric values.
Secondary Keypads:*	
1/STBY (Standby)	Initiates or exits Standby Mode
3/QC (Quality Control)	Initiates QC Test
7/TEMP (Temperature)	Initiates Temperature Correction feature
8/MENU	Displays Options Menu
9/PRINT	Reprints last Sample Report
0/STATUS	Prints Status Report

* Note:
Press SHIFT keypad then appropriate numeric keypad to initiate secondary keypad functions.

2.6 INSTALLING/CHANGING THE PRINTER PAPER

Note:
When a red stripe appears on the edge of the paper, there are approximately 2 feet of paper remaining, or enough for 5-6 sample analyses.

1. Open printer doors located on the side and the front of the GEM Stat.
2. Remove remaining printer paper and cardboard spool from spindle.
3. Place paper over the top of the roll and slide new paper roll onto spindle until roll "seats" (just past retaining ring).
4. Thread paper through printer as shown in Figure 2-2. Feed the paper 1 inch into the Printer mechanism.
5. Press "PAPER FEED" keypad located on front panel to automatically complete the paper thread.
6. Close both printer doors.

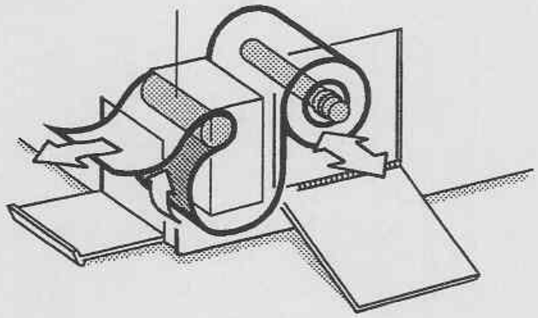


Fig 2-2, Adding Printer Paper

2.7 GEM STAT POWER UP INSTRUCTIONS

1. Plug GEM Stat line cord into a suitable power source.
2. Turn power on via rear rocker switch on back of the GEM Stat Instrument*. If using the Power Converter, plug the GEM Stat into the three pronged receptacle on the back of the Power Converter, then plug the Power Converter into any suitable power source. (See Appendix 5, "Power Converter" for specifications and use of the Power Converter.)

   The alphanumeric (red characters) display will display "SELF- TEST" for approximately 10 seconds. During "SELF TEST" all numeric display segments will light, appearing as all "8"s. You can now see if all of the numeric segments are functioning.

   Next the display will read "WAIT CLOCK1" and/or "WAIT CLOCK2" momentarily, then "PLEASE WAIT" for approximately 10 seconds, during which time the cartridge valve actuator is indexed to the SAMPLE position. The display will change to "INSERT CART."

   * Rocker Switch controls power to instrument and functions as a circuit breaker.

3. Verify that the Fan is operating quietly and blowing into the GEM Stat. You can do this in one of two ways:
    a. Hold a piece of paper near the fan and make sure it is pulled toward the instrument.
    b. Hold your hand near the fan and feel the fan pulling.

    If the fan is not operating, refer to Chapter 5, "Trouble-Shooting".

4. Verify that the date and time are correct.

    Press SHIFT-MENU then repeatedly press the MENU KEY UNTIL THE DISPLAY SHOWS "DATE/TIME?". Press ENTER. The date should be displayed in the alphanumeric display. If the U.S. format has been set, the display will show mm/dd/yy (month/day/year). If the International format has been set, the display will show dd/mm/yy (day/month/year). Check if the date is correct, then press the "ENTER" key. Time should now be displayed (in 24 hour format hh/mm/ss) with seconds incrementing at 1 second intervals.

    If either the date or time is incorrect it should be reset. For details on changing the date and time, refer to Section 3.5 "Date and Time".

Note:
The Date and Time can only be set when there is no cartridge is in the Instrument and the alphanumeric display reads INSERT CART.

2.8 INSERTING A NEW CARTRIDGE

It takes about 45 minutes from the time a new cartridge is inserted until a sample can be processed.

1. Examine the GEM Statpak to verify that its expiration date has not been exceeded.

2. Remove the GEM Statpak from its protective package. Make sure that the product and the packaging are completely dry. Do not use if there are any signs of moisture.

CAUTION
If there is any moisture inside bag or on cartridge or the dessicant package appears pink (blue is normal), do not use cartridge. Open a fresh GEM Statpak and call Customer Service.

3. Check that the message display reads "INSERT CART". If it does not, turn the power off and start over from GEM Stat power-up, Section 2.7.

4. Open the hinged cartridge door on the front of the instrument by turning the knob on the top of the door counterclockwise and pulling the door down.

5. Remove the protective cover from the GEM Statpak and immediately insert it into the cartridge compartment, aligning it according to the labeling.

> CAUTION:
> You must insert the cartridge into the GEM Stat instrument within one minute of removing the protective cover to ensure that calibration solutions do not leak from the cartridge.

6. Close the door. Turn knob counterclockwise and the door will automatically lock. Display should read "WARMUP MM:SS".

2.9 GEM STAT WARM-UP/HYDRATION MODE

As soon as the door is locked, the system goes into the warm-up mode. The display shows "WARM-UP 44:38", and begins a count-down. During the warm-up period, calibration solution "B" (Cal. B solution) is pumped into the electrode chamber and left for 30 minutes. This soaking period hydrates the electrodes.

After soaking the electrodes for 30 minutes, the system performs a two point calibration which involves the following:

1. Cal. B solution is pumped into the electrode chamber and held for 90 seconds (during which time the sensors come to chemical and thermal equilibrium).
2. The electrical response of all sensors to the Cal. B solution values are stored.
3. Air is flushed through to clear the chamber.
4. Cal. A solution is pumped into the electrode chamber and held for 90 seconds.
5. The electrical response of all sensors to Cal. A solution values are stored.
6. The stored values for the Cal. B and Cal. A measurements are used to determine sensor response line slopes.
7. Air is flushed through to clear the chamber.
8. Cal. B solution is pumped into the chamber and remains until sample is aspirated or until next automatic calibration occurs.

After a successful warm-up, the GEM Stat display reads, "READY 37°C", indicating that the GEM Stat is ready to process samples. If this is not the case, refer to Chapter 5, "Trouble-Shooting".

2.10 CUSTOMIZING THE SYSTEM, "HIDDEN" KEY FUNCTIONS

The GEM Stat has "Hidden Key Functions" that allow the user to customize the system. The name and default setting of these functions are shown in Table 2-1.

Option	Default Setting	Alternate Option Setting
Mandatory ID	ON	OFF
Mandatory QC	OFF	ON
Sample Label	OFF	ON
Analytes	Gases/Lytes/Hct	Gases/Hct, or Lytes/Hct
Measurement Units	mmHg	kPa
Date Format	U.S.	INTL
Counts	OFF	ON
Calibration Statistics	OFF	ON

Table 2-1, "Hidden Key" Defaults

How to change the hidden key status

1. Press these keypads in sequence: SHIFT, IDENT, SHIFT, 6 to access the OPTION MENU.
2. Press 8 to scroll the Options.
3. Press 9 to change the Option Setting.
4. When all options are set as desired, press ENTER.

Mandatory Quality Control

On Forces user to analyze at least one QC solution prior to running the first blood sample on a cartridge.

Off Allows samples to be tested with or without first having run QC solutions.

Mandatory ID

On Requests a patient and operator ID number prior to every analysis.

Off Does not request an ID number prior to aspirating sample. The ID number may be entered optionally by pressing the "IDENT" keypad.

System will retain previously entered patient and operator ID numbers until changed.

Date Format

U.S. Date will print as month/day/year.

INTL Date will print as day/month/year.

Counts

(Used for functional diagnostic tests, refer to Chapter 6)

On	Raw V/F counts for all channels digitized will be printed each time the electrode signals are digitized. Turn this feature ON only if you need to diagnose a problem.
Off	Raw V/F counts will not be printed.

Units of Measurement for Blood Gas Partial Pressures

kPa	Blood gas measurements will be reported in kilo-pascal units.
mmHg	Blood gas measurements will be reported in millimeters of mercury.

Sample Labeling

On	"Art 1 Ven2" will be displayed upon pressing the SAMPLE keypad. If you enter "1" the sample printout will be labeled "Arterial" at the top. If you enter "2" the printout will be labeled "Venous" at the top. (See Appendix 6 "Printouts",)
Off	System will not prompt for Arterial of Venous label. Printout will not be labeled.

Analyte selection (Gases/Lytes/Hct)

Toggling with the "9" key selects one of 3 combinations. (See Appendix 6. "Printouts").

Gases/Lytes/Hct	Prints and displays values for blood gases, electrolytes, and hematocrit.
Gases/Hct	Prints and displays values for blood gases and hematocrit only.
Lytes/Hct	Prints and displays values for electrolytes and hematocrit only.

Cal Stats

On	Calibration statistics will print following each hourly Two-Point Cal. and each One-Point Cal. every 30 minutes. The information will include electrode slope and drift values as well as measured bag values.
Off	Calibration statistics will not print. (See Appendix 6, "Printouts")

Calibration statistics for each cartridge is stored regardless of the Cal Stat setting. Therefore, the system can be operated with the Cal Stat off, then at a later point in the cartridge life the calibration statistics can be printed out if desired. Refer to Section 3.4.

CHAPTER 3; OPERATING INSTRUCTIONS

3.1 OPERATION SUMMARY

The primary operating modes are: READY, STANDBY and QC . A summary of each follows.

Ready mode

The system is READY after the cartridge warm-up is complete. See Chapter 2, "Installation and Preparation", for a description of the warm-up mode.

- When the GEM Stat is ready to accept samples, "READY 37.°C" is displayed. "37.°C" indicates the temperature at which the next sample will be measured.
- Blood or Quality Control samples may be aspirated for analysis, or the system can be placed into STANDBY to conserve cartridge life. A previously analyzed blood result may be temperature corrected.
- The active keys are: SAMPLE, SHIFT-TEMP, SHIFT-PRINT, SHIFT-STATUS, SHIFT-STANDBY, SHIFT-MENU, SHIFT-QC, and IDENT.
- During "READY" mode, automatic one and two point calibrations occurs at regular intervals.
- After the active run time on the cartridge has been used, or 50 samples have been processed, "REMOVE CART" will be displayed.

Standby mode

48 hours of STANDBY time are available. Standby time conserves active cartridge life. During Standby, the keyboard is not active, with the exception of the STANDBY menu and STATUS keys. Samples cannot be processed.

- To enter Standby, press the SHIFT keypad, then the 1 keypad.
- To exit Standby, press the SHIFT keypad, then the 1 keypad.

QC mode

Quality Control solutions are used to verify the calibration accuracy of GEM Stat. Three aqueous solution levels are provided to test all parameters except Hct throughout physio-logical ranges. Two solution levels are provided to test Hct performance. These solutions are comparable to those used to test standard bench top laboratory equipment, but were developed specifically for use with GEM Stat .

- To enter the QC mode, press the SHIFT keypad, then the 3/QC keypad. Follow the prompts on the alphanumeric display. The QC mode provides documentation that distinguishes a Quality Control sample from a patient blood sample.

3.2 HOW TO PROCESS A BLOOD SAMPLE

1. Collect the Blood

To assure the highest accuracy possible of each analysis, follow these steps:

A. Use a heparinized collection device (25 USP units/ml of sodium or lithium heparin) and obtain 3/4 to 1 cc of blood from the patient.

CAUTION

Use only heparinized blood for analysis. Unheparinized blood will cause irreversible sensor damage to the cartridge.

B. Minimize the introduction of air into the sample by "pushing" the dead air out of the syringe. Air contamination can change the gas values in the blood.

C. Invert the syringe immediately after purging air to mix the heparin and blood. The sample should be mixed again immediately prior to analysis to avoid erroneous Hct.

D. Store sample in ice if analysis cannot take place within 5 minutes of collection. Blood gas levels change rapidly.

2. Enter Patient and Operator Identification Numbers

A. Press IDENT. Alphanumeric display will show: "PA000000000" and ENTER keypad will Flash.

B. Use numeric keypad to enter the Patient ID number, up to nine digits. If numbers are not correct, press "CANCEL" and begin again.

C. Press ENTER when the patient ID number has been correctly entered. Alphanumeric display will show "OP000000000" (If an Operator ID number has been entered previously, it will replace the "0's" in the display.) If operator ID is correct, proceed to step E.

D. Use numeric keypad to enter Operator ID number. Alphanumeric display will show entered digits.

E. Press ENTER when Operator ID number has been correctly entered. ENTER light will stop flashing and display will return to its previous mode.

NOTE:
The operator ID and the patient ID are initialized to all 0's on power up or removal of the cartridge.

3. Aspirate the Sample

WARNING
Do not inject the sample into GEM Stat with a syringe. This will cause serious damage to both the cartridge and the instrument. Use the GEM Sampleraccording to the instructions.

A. Attach the GEM Sampler to the inlet of the GEM Statpak by sliding tubing into the inlet until it is inserted as far as it will go, indicated when the "STOP" line is flush with the opening (Fig 3-1).

B. Insert the open end of the GEM Sampler into a heparinized blood collection device.

C. Make sure that the open end of the sampler is immersed in the blood sample so that you can aspirate 0.5 cc of blood (Fig 3-2).

D. Press the SAMPLE keypad. Display will read, "SAMPLING" during blood aspiration.

E. Hold the blood sample in position until the display changes to, "PROCESS 1:50".

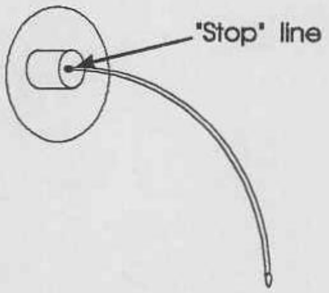


Fig 3-1, Make sure that the "Stop-line" is flush with the cartridge.

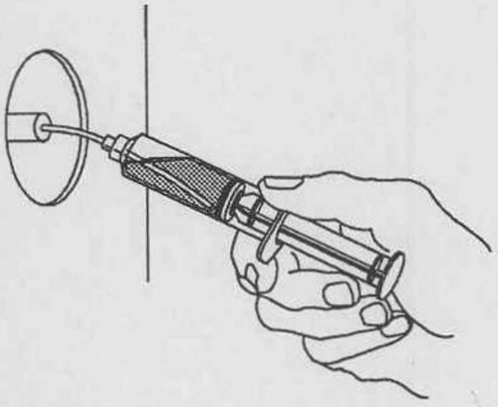


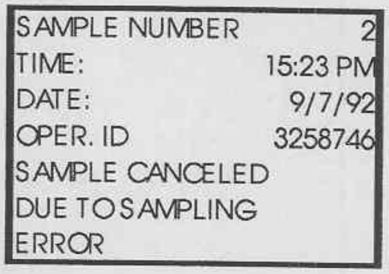
Fig 3-2, Immerse the sampler in the blood, then press the START keypad.

NOTE:
It is recommended to use a new GEM Sampler for every sample analyzed.

Warning
If air is aspirated press CANCEL to abort the sample test.

Software in the GEM Stat tests for conditions that indicate that air has been aspirated. When this occurs a Sample Canceled Message is printed instead of the Normal Sample Printout, Fig. 3-3.

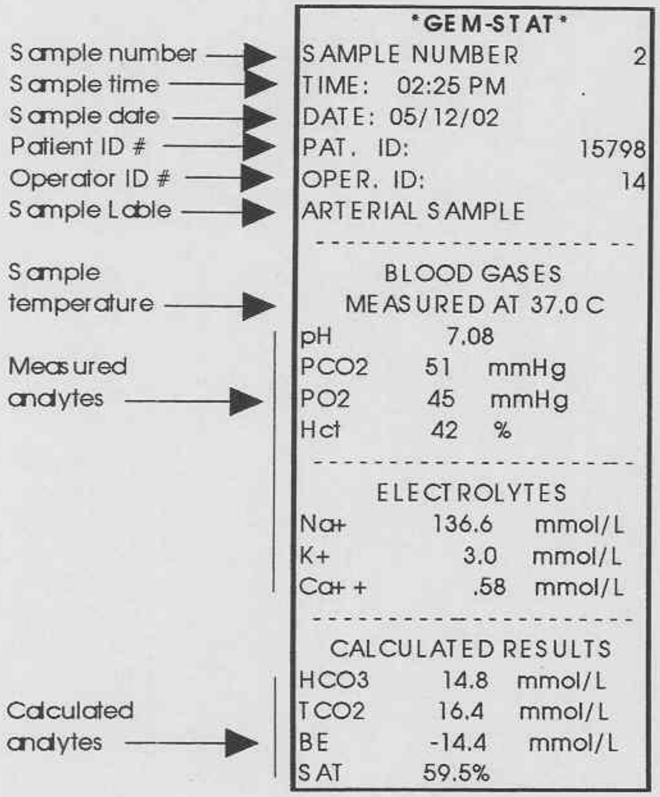
In this case, the test must be redone.



```
SAMPLE NUMBER          2
TIME:           15:23 PM
DATE:             9/7/92
OPER. ID         3258746
SAMPLE CANCELED
DUE TO SAMPLING
ERROR
```

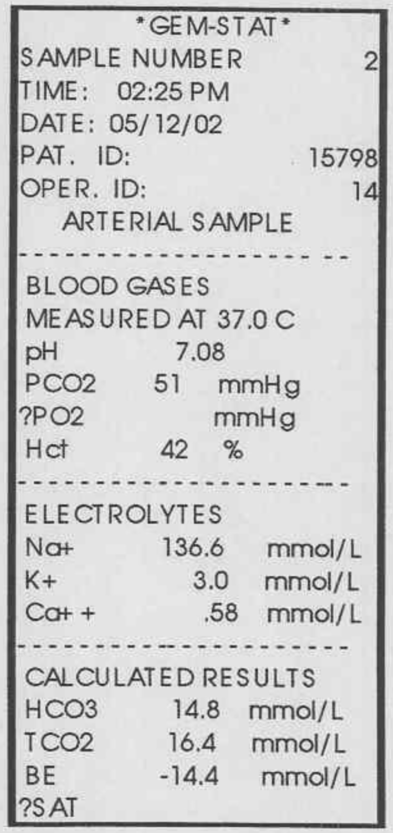
Fig. 3-3, Canceled Sample Message.

4. Interpret the Printout:



```
        *GEM-STAT*
SAMPLE NUMBER              2
TIME:   02:25 PM
DATE: 05/12/02
PAT.  ID:              15798
OPER. ID:                 14
ARTERIAL SAMPLE
- - - - - - - - - - - - - - -
       BLOOD GASES
   MEASURED AT 37.0 C
pH          7.08
PCO2      51    mmHg
PO2       45    mmHg
Hct       42    %
- - - - - - - - - - - - - - -
       ELECTROLYTES
Na+         136.6    mmol/L
K+            3.0    mmol/L
Ca++          .58    mmol/L
- - - - - - - - - - - - - - -
    CALCULATED RESULTS
HCO3        14.8   mmol/L
TCO2        16.4   mmol/L
BE         -14.4   mmol/L
SAT        59.5%
```

Fig. 3-4; Normal Sample printout



```
         *GEM-STAT*
SAMPLE NUMBER              2
TIME:   02:25 PM
DATE: 05/12/02
PAT.  ID:              15798
OPER. ID:                 14
    ARTERIAL SAMPLE
- - - - - - - - - - - - - - -
BLOOD GASES
MEASURED AT 37.0 C
pH          7.08
PCO2      51    mmHg
?PO2            mmHg
Hct       42    %
- - - - - - - - - - - - - - -
ELECTROLYTES
Na+         136.6    mmol/L
K+            3.0    mmol/L
Ca++          .58    mmol/L
- - - - - - - - - - - - - - -
CALCULATED RESULTS
HCO3        14.8   mmol/L
TCO2        16.4   mmol/L
BE         -14.4   mmol/L
?SAT
```

Fig. 3-5 Sample printout with O2 Sensor Problem.

Sample Printouts with Missing Values

There may be cases when the printout and the display are blank for an analyte and "?" appears before the analyte name in the printout. This indicates that the sensor(s) did not pass their last calibration or that the sample result was outside of a preset range.

For example, Figure 3-5 is a sample printout with a bad oxygen (O_2) sensor therefore both the O_2 and analytes derived from O_2---SAT (Oxygen Saturation) in this case---are not reported.

Derived Parameters

The derived parameters: BE, TCO_2, HCO_3, and SAT are derived from calculations using measured parameters. If any of the measured parameters used in the calculation is out of specification, the corresponding calculated (derived) parameter is also considered inaccurate and appears blank on the display and printout.

Derived Parameter	Measured Parameter(s) Used
SAT	PO_2 , Hct
TCO_2	PCO_2, pH
HCO_3	PCO_2 pH
BE	PCO_2, pH, Hct

Table 3-1, Measured Parameters used to calculate Derived Parameters

5. Normal physiological blood ranges.

Table 3-2 provides normal whole blood ranges for each GEM Stat measured parameter. These ranges should be considered only as a guideline. Also, the expected results for different patient populations can vary. Each institution should determine the appropriate range of expected values for use with its own patient population(s).

Parameter	Arterial	Venous	Reference
pH	7.38-7.44	7.36-7.41	(1)
PCO_2	35-40	40-45 mmHg	(1)
PO_2	95-100	*	(1)
HCO^-_3	21-28	*	(1)
TCO_2	19-24	*	(1)
BE	-3.3 to +2.3	*	(1)
SAT	94-100	*	(1)
Hct	37-50	37-50	(2)
Na^+	136-142	136-142	(1)
K^+	3.8-5.0	3.8-5.0	(1)
iCa^{++}	1.0-1.3	*	(1)

Table 3-2, Normal expected values for whole blood

* NOTE (referring to Table 3-2)
Venous parameters marked with an asterisk (*) can vary substantially between individuals and venipuncture sites.

REFERENCES (for values in Table 3-2):

1. Davidsohn, I., and Henry, J.B.: Todd-Sanford Clinical Diagnosis by Laboratory Methods, W.B. Saunders Co., Philadelphia, 15th Edition, 1974.
2. Tietz, N.W., Fundamentals of Clinical Chemistry, W.B. Saunders Co., Philadelphia, 1982.

CAUTION

Patients that have severely abnormal plasma osmolarities cause the GEM Stat hematocrit values to differ from those produced by a cell counter. In general, abnormally high plasma osmolarity will cause the GEM Stat hematocrit to read low relative to a cell counter.

3.3 OPERATOR PERFORMANCE CHECKS

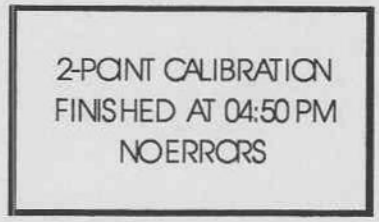
Accuracy of the GEM Stat system is maintained via automatic One and Two-Point calibrations that occur at programmed intervals without user intervention. Accuracy can be verified at any time by the operator using GEM Check and GEM Crit Check QC solutions.

Calibration (Refer to Section 4.3, "Calibration System")

One-Point Calibrations (1-Point Cal.) occur automatically for all sensors every 90 seconds. The 1-Point Cal. is invisible to the operator and is used to continuously adjust for sensor drift throughout the cartridge life. If you begin sample aspiration just prior to the time a 1-Point Cal. is due, it will be delayed and begin after the sample is processed. If the 1-Point Cal. process is in progress when the SAMPLE button is pressed, the 1-Point Cal. stops so that you may proceed.

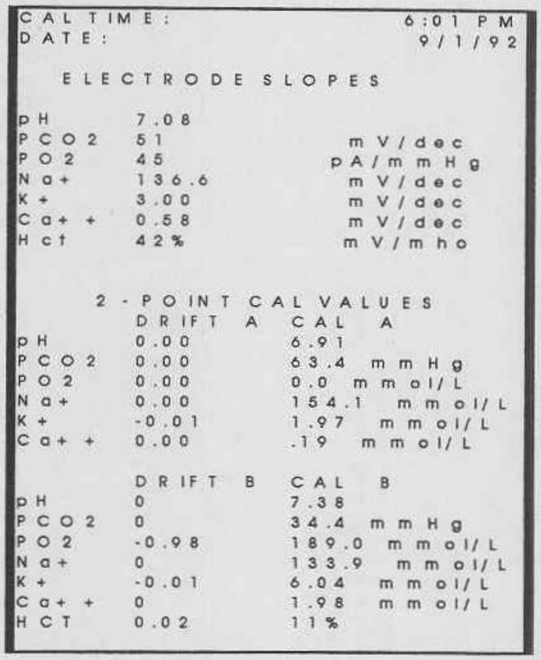
Two-Point Calibrations (2-Point Cal.) occur automatically every 60 minutes*. During a 2-Point Cal. the slope of each sensor's performance is checked and readjusted. If the slope or slope change since the previous 2-Point Cal. is greater than a preset limit, a sensor failure will occur which causes the measured value and any derived values to be blanked in the display and printout after sample and QC tests. If you begin sample aspiration just prior to a 2-point Cal, the 2-Point Cal. will be delayed and begin after the sample is processed. Once a 2-point Cal. is in process it cannot be interrupted.

There are two types of 2-Point Cal. reports that will printout following each 2-Point Cal. A Calibration Message like that shown in Figure 3-6 is printed if the Cal Stat option is off or a Calibration Statistical Report like the one shown in Figure 3-7 is printed if the Cal Stat option is on.



```
2-POINT CALIBRATION
FINISHED AT 04:50 PM
NO ERRORS
```

Fig. 3-6. 2-Point CAL Message



```
CAL TIME:                          6:01 PM
DATE:                               9/1/92

    ELECTRODE SLOPES

pH       7.08
PCO2     51                      mV/dec
PO2      45                    pA/mmHg
Na+      136.6                   mV/dec
K+       3.00                    mV/dec
Ca++     0.58                    mV/dec
Hct      42%                     mV/mho


         2-POINT CAL VALUES
         DRIFT A     CAL A
pH       0.00        6.91
PCO2     0.00        63.4 mmHg
PO2      0.00        0.0 mmol/L
Na+      0.00        154.1  mmol/L
K+       -0.01       1.97  mmol/L
Ca++     0.00        .19  mmol/L

         DRIFT B     CAL B
pH       0           7.38
PCO2     0           34.4 mmHg
PO2      -0.98       189.0  mmol/L
Na+      0           133.9  mmol/L
K+       -0.01       6.04  mmol/L
Ca++     0           1.98  mmol/L
HCT      0.02        11%
```

Fig. 3-7, 2-Point Cal Stat Report

* Except after warmup. 2-Point Cal. occurs (20) minutes after new cartridge is installed

Description of Calibration failure detection.

If the performance of one or more of the sensors is outside specified limits, all of the following will occur:

- The Calibration Printout will indicate the failed sensor (refer to Appendix 6).
- The failed sensor message will be printed on subsequent status printouts until the sensor falls into specification (which often happens with the next 2-Point Cal.).
- Any measurements made by the failed sensor will be "blanked out" on the corresponding window display. The analyte in question will have a "?" next to it on the sample printout.

Correcting a Calibration failure.

If a calibration failure is indicated on the calibration printout, initiate a 2-Point Cal. as outlined below. If the 2-Point Cal. failure persists---the cartridge should be replaced. If calibration failure(s) persist over multiple cartridges, refer to Section 5.8 in the Trouble-Shooting Chapter.

Note:
Occasionally, a "?" may appear next to an analyte on the sample printout even though the previous 2-Point Cal. was successful. This indicates that the sample was beyond a preset range which is usually the result of a sample handling problem. Immediately request a Status Report by pressing SHIFT, then 0/STATUS. If the Status Report does not indicate a problem with the previous calibration checks -- simply retest a fresh sample.

Reasons to Initiate a 2-Point Calibration.

You may manually initiate a calibration in order to:

1. Readjust sensor slopes quickly instead of waiting for the next automatic 2-Point Cal..
2. Correct for an unexplained sensor failure in the previous 2-Point or 1-Point Cal.

NOTE:
In order to conserve CAL-B solution, a 2-Point Cal. should be initiated no more than 4 times per cartridge.

How to initiate a 2-Point Calibration:

1. Press SHIFT keypad, then 8/MENU keypad. Alphanumeric display will read "2-PT. CAL." and ENTER indicator light will flash.
2. Press ENTER. A 2-Point Cal. will occur.

Quality Control (QC)

Mallinckrodt Sensor Systems QC Solutions (GEM Check and GEM Crit Check) verify that the system is functioning within the performance specifications set by Mallinckrodt Sensor Systems. The solutions are manufactured with *known concentrations*of pH, PO_2, PCO_2, K^+ iCa^{++}, Na^+, and Hct. Multiple levels are included so that performance can be verified over a wide range.

WARNING
Use only MSS Quality Control Solutions. Solutions designed for use with other instruments can produce erroneous results and may damage the GEM Statpak sensors.

To verify system performance, the values obtained from solution analysis are compared with the "Expected Values" printed on the QC package insert . For a complete description, refer to the product insert provided with each quality control product.

System verification frequency is determined by your quality control program. Many federal and state regulatory requirements dictate that all three levels of GEM Check solutions are run each day.

Should additional information regarding Quality Control be required, Mallinckrodt Sensor Systems Quality Assurance Manual (Prod. No. 380023) contains descriptions, procedures, and data recording information for QC checks and is available from the factory upon request.

CAUTION
Stability of quality control solution degrades quickly after opening glass ampule. Proceed with sample analysis within 1 minute after opening ampule.

NOTE:
The printout will not distinguish the QC solution from a patient blood sample unless the sequence described below is followed, and the alphanumeric display reads "QC READY."

How to analyze a QC solution. (System must be in the READY mode.)

1. Press SHIFT, then the 3/QC keypad. Alpha-numeric display will read "LN0000?" and the ENTER keypad will flash.
2. Use the numeric keypads to enter the lot number that is printed on the label of each QC ampule (fig 3-8). Alphanumeric display shows the entered digits and the ENTER keypad will flash.
3. Press ENTER. Alphanumeric display will read "QC READY." QC must be processed within one minute of entering ID number or instrument will revert to READY mode.

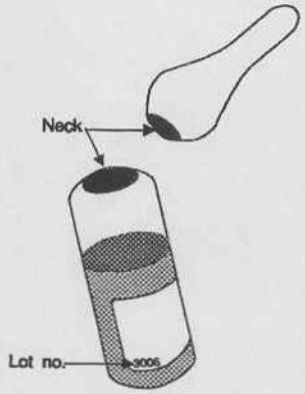


Fig 3-8, Location of lot no. on QC ampule.

4. Gently swirl ampule for 10 seconds to mix. Then snap off at neck (Fig. 3-8).

> CAUTION
> We recommend that the top portion of the ampule be wrapped in a 2 x 2 gauze pad or equivalent to avoid a skin puncture.

5. Place GEM Sampler to the bottom of the ample then press START to aspirate the solution from glass ampule (Fig. 3-9).

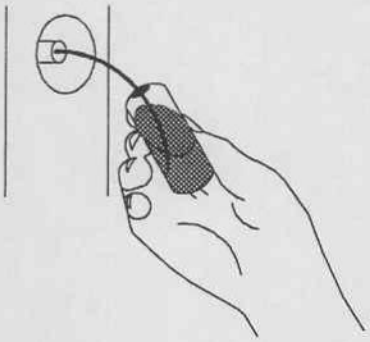


Fig 3-9, Aspirating solution from QC ampule.

6. Interpret the results by comparing the instrument readings with the "Expected Values" on the package insert provided with the quality control Solutions. Be sure to refer to the "GEM Stat" values.
7. If the instrument readings are outside the limits of any of the published "Expected Ranges," immediately re-test the same level with a new ample using the above protocol. If results again are outside of the "expected range," initiate a 2-Point calibration and repeat the same level with another new ampule. If the results are still outside the "expected range," refer to Section 5.9, "QC Problems or Failures".

3.4 RECORD KEEPING AND REPRINTING

The GEM Stat begins storing data as soon as a cartridge is inserted into the instrument. The GEM Stat stores cartridge data during and after cartridge use or removal. It will even store the data if the power has been turned off. However, all previous cartridge data is lost when the next cartridge is installed. You can obtain duplicate printouts of all transactions that have taken place since the cartridge has been inserted.

Printing Duplicate Records

Note:
All cartridge data is stored until a new cartridge is inserted.
Records can be printed after a cartridge is removed or while the cartridge
is still in the instrument.

Print Function	Description of Printout
Print Last Sample	Reprints last Blood or QC test
Print All	Reprints all QC and Blood tests
Print QC	Reprints all QC tests
Print Day	Reprints all QC and Blood tests for that day
Print Last Cal	Reprints last 2-Point CAL
Print All Cal	Reprints all 2-Point CAL's

Table 3-3, Reprint Options

Note:
"Print last cal" and "Print all cal" is available only when "Cal Stat" option is"on" (see Customizing the System, "Hidden Key Functions, section 2-10).

Note:
Before starting a reprint, check your instrument paper supply.
Some reprints are long and will require a significant paper supply.
This step can save you time and frustration.

To reprint a copy of the last sample analysis.

Press SHIFT, then 9/PRINT keypad. The previous printout will be duplicated.

To reprint QC records, Blood analyses, or Calibration records.

1. Press the SHIFT, then the 8 keypad.
2. Press 8 repeatedly to view each of the MAIN MENU selections.
3. When the reprint Selection you desire appears on the display, press ENTER. The printer will begin generating the printouts you have selected. When the printout is completed, the GEM Stat will perform a rinse, then return to the previous mode.

> Note:
> Calibration statistics for each cartridge are stored regardless of the Cal Stat setting. Therefore, the system can be operated with the Cal Stat off then at a later point in the cartridge life the calibration statistics can be printed.

For example, to PRINT ALL:

1. Press SHIFT keypad then 8/MENU keypad. Alphanumeric display will read "2 PT. CAL." and ENTER keypad will flash.
2. Repeatedly press the 8 keypad to scroll to until the selection "PRINT ALL" appears in the alphanumeric display. You will need to press it up to four times.
3. Press ENTER. GEM Stat will print all QC and sample tests that have occurred since cartridge was inserted

3.5 MISCELLANEOUS FUNCTIONS

Paper feed

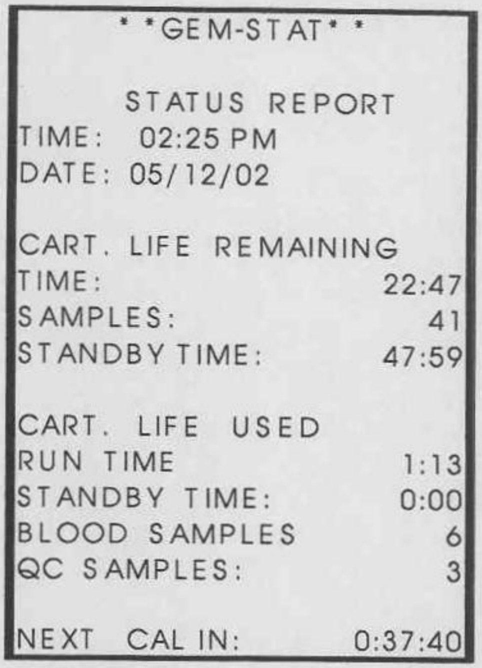
Press the Paper Feed keypad to advance the paper . This is used primarily when adding new paper.

Cartridge Status

The Cartridge Status print out informs you of several aspects pertaining to the status of the GEM Statpak disposable cartridge. See Figure A6-6 for printout examples.

How to print the cartridge status.

Press SHIFT, then O/STATUS keypad. Information is printed as shown in Fig. 3-10.



```
      * *GEM-STAT* *

      STATUS  REPORT
TIME:   02:25 PM
DATE: 05/12/02

CART. LIFE  REMAINING
TIME:                  22:47
SAMPLES:                  41
STANDBY TIME:          47:59

CART.  LIFE  USED
RUN  TIME               1:13
STANDBY  TIME:          0:00
BLOOD  SAMPLES             6
QC  SAMPLES:               3

NEXT   CAL  IN:      0:37:40
```

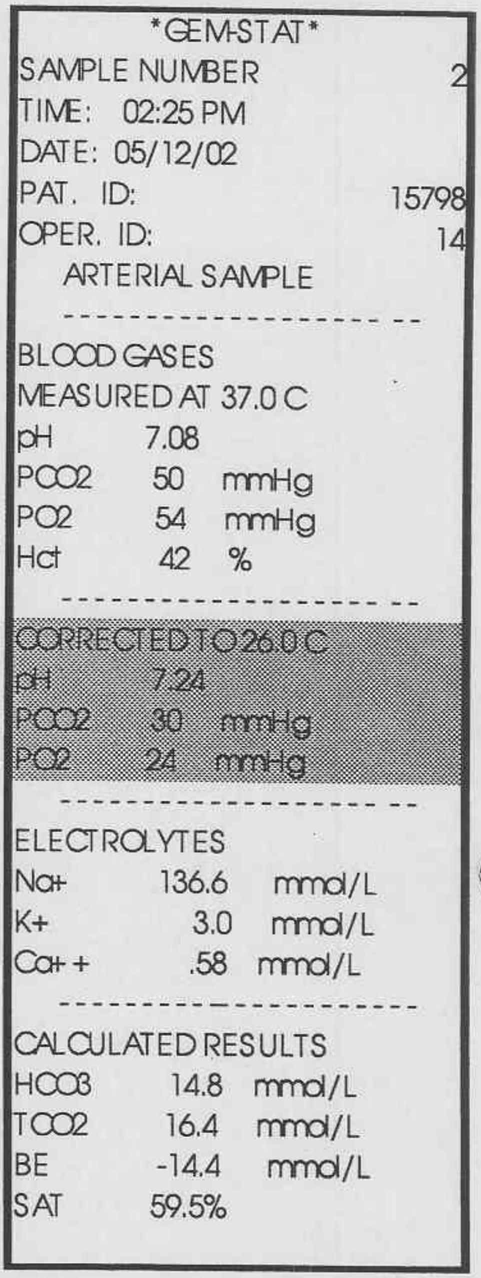
Fig. 3-10, Status Report

Temperature Correction

The GEM Stat System always analyzes the current blood sample at 37.0°C. You may prefer to calculate blood gas values to the patient temperature (which may be different than 37.0°C). The GEM Stat can calculate a previously analyzed blood sample to the desired temperature. Only the most recently analyzed blood sample can be temperature corrected. See Figure 3-11 for an example of this printout.

How to temperature correct a blood sample.

1. Press SHIFT, then 7/TEMP keypad. Display will read: "T = 37.0^{o}C?" and ENTER keypad will flash.
2. Use numeric keypad and enter 3 digits that signify the temperature (to the nearest 0.1^{o}C). Alphanumeric display will show the entered digits. If numbers are not correct, press "CANCEL" and begin again.
3. A printout will print with corrected blood values (Fig. 3-11).



```
          *GEM-STAT*
SAMPLE NUMBER                2
TIME:  02:25 PM
DATE:  05/12/02
PAT.  ID:                15798
OPER. ID:                   14
   ARTERIAL SAMPLE
   ---------------------- --
BLOOD GASES
MEASURED AT 37.0 C
pH          7.08
PCO2         50   mmHg
PO2          54   mmHg
Hct          42   %
   ---------------------- --
CORRECTED TO 26.0 C
pH          7.24
PCO2         30   mmHg
PO2          24   mmHg
   ---------------------- --
ELECTROLYTES
Na+          136.6    mmol/L
K+             3.0    mmol/L
Ca++           .58   mmol/L
   ------------------------
CALCULATED RESULTS
HCO3         14.8   mmol/L
TCO2         16.4   mmol/L
BE          -14.4    mmol/L
SAT         59.5%
```

Temperature Corrected to 26.0C

Fig. 3-11, Temperature Corrected printout

Standby mode

The 72-hour cartridge life is comprised of two phases: a 24-hour ACTIVE sampling phase and a 48-hour STANDBY phase.

The ACTIVE sampling phase of the GEM Statpak is the cartridge running time. During the active sampling phase blood and QC samples can be performed.

To preserve the limited sampling hours of each cartridge, the GEM Stat can be placed into STANDBY thereby extending the useful life for up to 72 hours.

When the calibrating solutions have been depleted, the active phase (useful life) of the cartridge is over.

The 24-hour ACTIVE life can be interrupted at any time, as often as desired, for up to 48 hours, allowing the cartridge to be used over a total period of 72 hours.

> Note:
> Blood and QC Samples can only be tested in the ACTIVE sampling Mode

The instrument automatically monitors the amount of active time and standby time that has been used which is printed on the status printout. If either active or standby time is exceeded, the GEM Stat displays the appropriate message.

The total cartridge running time (active) cannot exceed 24 hours. Instrument will display "Remove cart" when all 24 hours of running time have been used.

Total cartridge standby time cannot exceed 48 hours. Instrument will display "READY" if the full 48 hours of standby have been used and there is active life remaining.

How to enter standby.

Press SHIFT and then the 1/STDBY keypad. Alphanumeric display will read "GOING 2 STBY" for about 5 seconds. System will finish what it is doing, e.g., rinse, calibrate, etc. The display will read "STANDBY" and remain in STANDBY until signaled to exit.

How to exit standby.

Press SHIFT and then the 1/STDBY keypad. Alphanumeric display will read "EXITING STBY" for 0-90 seconds, then read "RINSE 3:46." A 2-point calibration may occur.

Date and time

You can only set the date and time while there is no cartridge in the instrument and the display reads "INSERT CART". The date and time have been set by the factory but can be changed as required by the operator.

How to change the date and/or time.

1. Press SHIFT, then the 8/MENU keypad (You may have to press the 8/MENU keypad twice). Alphanumeric display will read "DATE/TIME", and ENTER keypad will flash.
2. Press ENTER. Alphanumeric display will read the date and ENTER keypad will flash.
3. If displayed date is incorrect, go to step 4. If it is correct, press ENTER. Display will read the time and ENTER keypad will flash. If time is incorrect, proceed to step 7. If the time is correct, go to step 8.
4. If displayed date is incorrect, enter 6 digits that signify the date (2 each for the month, day, and year). Alphanumeric display will show the entered digits. ENTER keypad will flash.
5. Press ENTER. Alphanumeric display will read the set time and ENTER keypad will flash.
6. If displayed time is correct, press ENTER. Instrument will return to "INSERT CART" and keep the date and time set until it is changed. Proceed to the next section.
7. Enter 6 digits that signify the time (2 each for the hour, minute and second). "AM" and "PM" are not read by the instrument, so use military standard, e.g., 2:12:00 PM must be entered as 14:12:00. Alphanumeric display will show the entered digits. ENTER keypad will flash.
8. Press ENTER. Instrument will return to the mode it was in, and will keep track of the date and time until it is changed.

3.6 POWER INTERRUPTION

GEM Stats' small size and ability to maintain critical systems during power interruptions make it ideal for transport. The system can be disconnected from its power source, transported, and remain completely functional provided that:

- The cartridge has not been removed and has been inserted for at least 7 seconds.
- The power is restored within 30 minutes.
- Blood is not in the sensor chamber for more than 20 minutes. (i.e. the power was not turned off during the "PROCESS" mode.

To transport, simply disconnect from power source. When the power is reconnected, the display will read PLEASE WAIT, then RECOVERING. A printout will document the time of power interruption and power restoration. Following RECOVERING, a rinse and calibration will occur if they are due, before the system returns to READY.

If power was removed for more than 30 minutes or if blood has been in the chamber for more than 20 minutes, "REMOVE CART" is displayed. In this case, you must remove the cartridge, which causes the system to go to "SELF TEST", "PLEASE WAIT", and "INSERT CART" modes. You may insert a new cartridge after "INSERT CART" is displayed.

3.7 CARTRIDGE REMOVAL

The cartridge door lock virtually eliminates the possibility of the cartridge door being inadvertently opened. The door will unlock automatically when the cartridge life has expired. To unlock the door and remove a cartridge before the use life expires:

A. Turn the unit OFF.

or,

B. Use the following key sequence:

- Press SHIFT, then the 8/MENU keypad until the display reads "REMOVE CART?".
- Press ENTER. Alphanumeric display will read "R U SURE?" and ENTER keypad will flash.
- To verify that you wish to remove the cartridge, press ENTER keypad again. The display will read "REMOVE CART" and the door will unlock.
- You may press CANCEL any time prior to the last step to return to the previous operating mode.

CHAPTER 4; THEORY OF OPERATION

4.1 OVERVIEW

GEM Stat is a highly automated system for measuring blood gases, electrolytes and hematocrit values at the point of patient care.

The sensor methodology is similar to what has been used in laboratory based analyzers for years. The primary distinction between GEM Stat and standard analyzers is in the component packaging which substantially affects how the system is operated in the clinical setting. The system has been designed so that all of the elements that traditionally require maintenance reside in a disposable cartridge. Rather than maintaining these elements over a long time period, they are simply discarded after 50 samples or 3 days, whichever comes first.

Figure 4-1 is a simple block diagram of the GEM Stat System. Its functional components are similar to other microprocessor-controlled blood chemistry analyzers utilizing electrochemical sensors. The system can be divided into two parts: (1) electro-mechanical section (GEM Stat), and (2) electrochemical, or "wet" section (consisting of the disposable cartridge--GEM Statpak).

4.2 MAJOR COMPONENT DESCRIPTION

GEM Statpak Cartridge (refer to Fig. 4-1)

Each disposable GEM Statpak Cartridge contains two calibration solution bags, a reference solution bag, the electrode array or "sensor card", a 3-position valve, and a waste bag.

Note:
No external gas tanks, rinse solutions, etc. are required for GEM Stat operation.

The two calibration solutions, referred to as "Cal A" and "Cal B" contain known quantities of salts and pre-tonometered gases with a high and low value for each parameter. During calibration, these solutions are pumped across the electrodes. If calibration values exceed allowed limits, the sensor fails calibration. All results for subsequent patient blood and QC samples are blanked out for the failed sensor and any derived values on both the display and prinouts. Thus, all reported GEM Stat results are measured by sensors that have successfully been calibrated.

During operation, a stepper motor located in the instrument actuates a 3-way cartridge selector valve located in the cartridge and selects one of the two calibration solutions or the sample inlet. A peristaltic pump located in the instrument moves the selected Cal. solution or blood into the Sensor Chamber and eventually into the Waste Bag.

The electrodes, contained in the Sensor Chamber on a plastic card, measure an electrical characteristic of the blood which is related to the measured parameter. The sensors are electrically connected to the GEM Stat Instrument. (Refer to Section 4.3 for more information about sensor methodology).

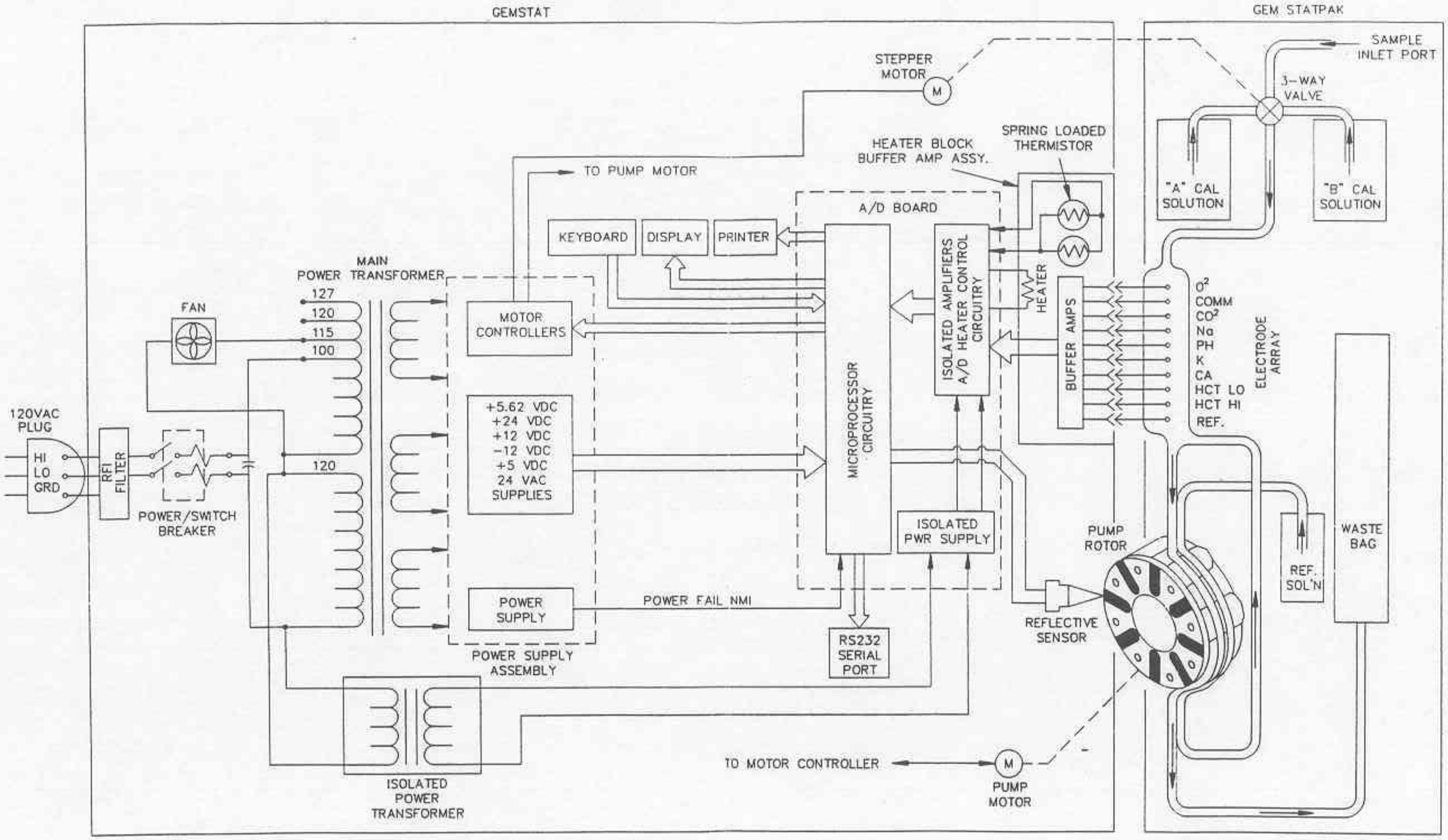

GEMSTAT
GEM STATPAK
SAMPLE INLET PORT
3-WAY VALVE
"A" CAL SOLUTION
"B" CAL SOLUTION
STEPPER MOTOR
M
TO PUMP MOTOR
HEATER BLOCK BUFFER AMP ASSY.
SPRING LOADED THERMISTOR
A/D BOARD
KEYBOARD
DISPLAY
PRINTER
MAIN POWER TRANSFORMER
127
120
115
100
120
FAN
120VAC PLUG
HI
LO
GRD
RFI FILTER
POWER/SWITCH BREAKER
MOTOR CONTROLLERS
+5.62 VDC
+24 VDC
+12 VDC
−12 VDC
+5 VDC
24 VAC
SUPPLIES
POWER SUPPLY
POWER SUPPLY ASSEMBLY
POWER FAIL NMI
MICROPROCESSOR CIRCUITRY
ISOLATED AMPLIFIERS A/D HEATER CONTROL CIRCUITRY
HEATER
BUFFER AMPS
O2
COMM
CO2
Na
PH
K
CA
HCT LO
HCT HI
REF.
ELECTRODE ARRAY
ISOLATED PWR SUPPLY
RS232 SERIAL PORT
PUMP ROTOR
REFLECTIVE SENSOR
REF. SOL'N
WASTE BAG
ISOLATED POWER TRANSFORMER
TO MOTOR CONTROLLER
M
PUMP MOTOR

Fig 4-1; GEM Stat System, Simple Block Diagram.

GEM Stat instrument

Buffer Amplifier and Heater Block Assembly

The heater block assembly is a receptacle for the electrode card portion of the disposable cartridge. It contains a high-impedance buffer amplifier for all electrodes except hematocrit and common. The buffer amplifiers are necessary because the electrodes present very high impedance signals which must be buffered prior to processing.

The heater block assembly consists of a two-section aluminum block which is regulated at 37° C. There are two thermistors in this block. One is spring-loaded and contacts a thin aluminum plate on the back of the electrode card, thus sensing the temperature of the card. A second is in close contact with the heater to prevent large temperature over- or under-shooting. The thermal control loop is of the on-off, or "bang-bang" type. The thermistors connect to a comparator in the isolated analog circuitry of the A-D Board. The output of the comparator controls a solid-state relay which switches power to the heater.

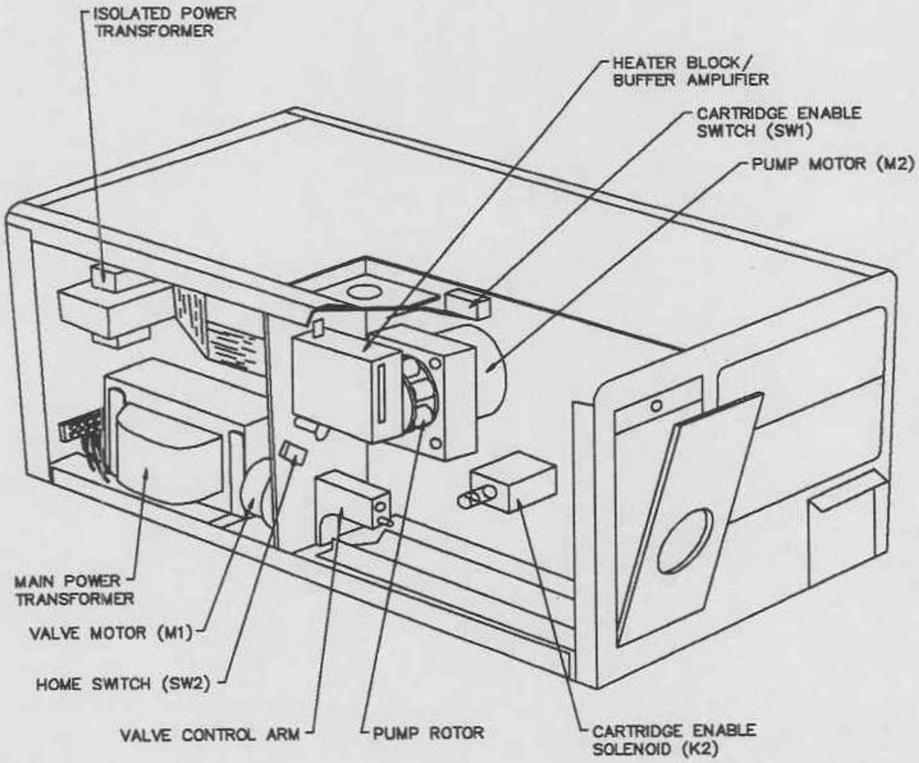

ISOLATED POWER TRANSFORMER
HEATER BLOCK/ BUFFER AMPLIFIER
CARTRIDGE ENABLE SWITCH (SW1)
PUMP MOTOR (M2)
MAIN POWER TRANSFORMER
VALVE MOTOR (M1)
HOME SWITCH (SW2)
VALVE CONTROL ARM
PUMP ROTOR
CARTRIDGE ENABLE SOLENOID (K2)

Figure 4-2 (1 of 2), GEM Stat, Major Components

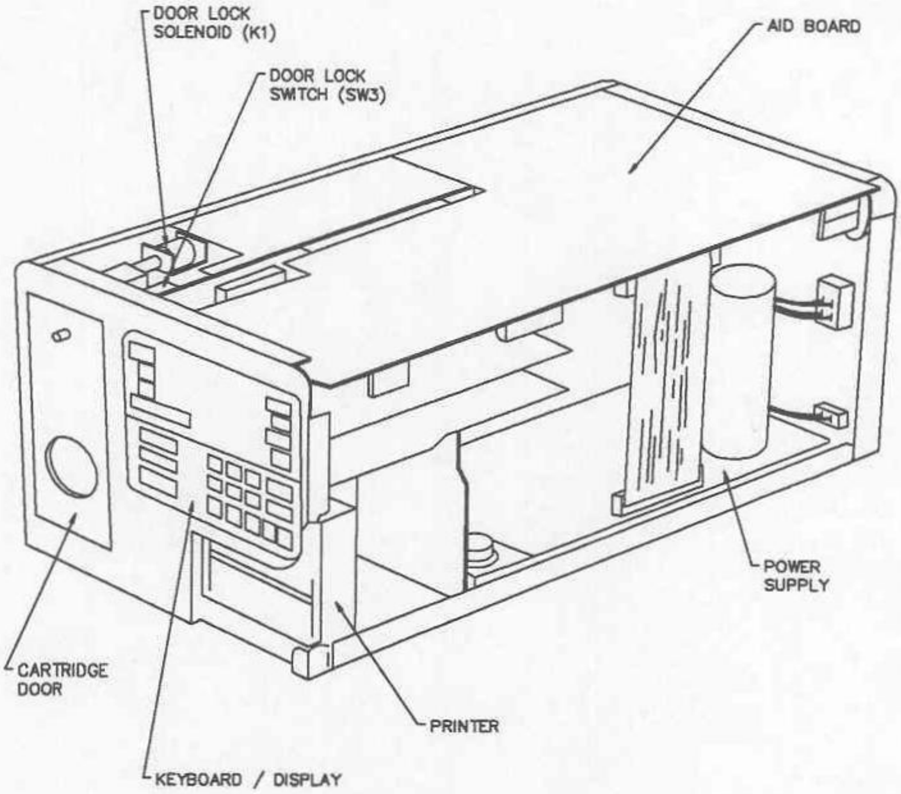


Figure 4-2 (2 of 2), GEM Stat, Major Components

Analog-Digital Circuit Board Assembly

This is the large main circuit board which contains differential amplifiers for processing the electrode signals, amplifiers for scaling signals from external thermistors, heater control circuitry, a voltage-to-frequency converter, and the microprocessor circuitry. The analog circuitry is isolated from the other parts of the system, and powered by a special isolation transformer. Electrical signals are carried between this circuitry and the microprocessor section through optical isolators.

The microprocessor section is comprised of the central processing unit (CPU), random access memory, which stores sample values and other variable data. The operating system software is read-only memory. Input/output (I/O) devices feed data to the display, printer, and control motors, and receive input signals from status switches and the key-board. A real-time calendar clock provides date and time information for time-keeping and the printed record. A small battery on the board maintains information in the RAM and the calendar clock during power off periods.

Thermal Printer

The printer is a 20-column fixed-head thermal unit. It is controlled by microprocessor circuitry on a small circuit board supplied by the printer manufacturer. Data to be printed is routed from the A/D board to the printer controller board.

Display Assembly

The display assembly consists of two sections-- a numeric display area for display of sample values, and an alphanumeric display for showing instrument operating modes, time and date, patient and operator I.D. numbers, and other information. A discreet L.E.D. is also located on this assembly which back-lights a targeted key on the keyboard.

Keypads

This elastomeric keyboard overlay is used to enter commands and data into the instrument. Operational functions are controlled by the operator using the keypads. The keyboard overlay also incorporates colored filters for the displays.

Power Supply Assembly

This contains the DC. regulators which supply power to the motor controllers for the pump and valve motors, and to other digital instrument parts. A power monitor circuit generates an interrupt to the microprocessor if power supply voltages drop lower than a present minimum level, such as when power is turned off or interrupted. Capacitors on the power supply maintain power to the processor long enough to perform some time-keeping functions and store away instrument status data, so that operation can be resumed when power is restored within 30 minutes.

Pump Motor

A synchronous A-C Pump Motor (M2) drives the Pump Roller which pumps fluids in the cartridge. The Pump Roller has an optical encoder painted on the inside face which is sensed by a reflective sensor. This is to assure that the Pump Roller can be stopped with the rollers in a certain relationship to the exposed tubing on the cartridge.

Valve Motor

The Valve Motor (M1) drives the Valve Control Arm that operates the cartridge valve. It is a stepper motor so that precise valve positioning can be obtained. A micro switch (SW2) provides a "home" 10:00 reference point, from which all valve positions are referenced by applying the required number of steps to the motor. The "home" reference point places the valve to allow the "Cal-B" calibration solution into the sensor chamber. When the actuator arm is at the 6:00 position, as in the "INSERT CART" mode, the sample port on the cartridge is selected. The 2:00 position of the arm allows the "Cal-A" calibration solution into the cartridge.

Door Lock and Cartridge Lock-Out Solenoids

Two solenoids control access to the cartridge compartment. The Cartridge Enable Solenoid (K2) prevents inserting a cartridge when the instrument is NOT at the "Insert Cart" display. The Door Lock solenoid (K1) locks the door after cartridge insertion to prevent opening of the door, which could cause faulty valve operation and/or unintended removal of a cartridge.

RS-232 Port
This output-only port allows connection to a remote data-collection system or monitor. All data on GEM Stat system printouts is transmitted to this port.

Software Operating System
The Operating System is the software contained on three read-only Memories on the A/D Board. This software is made up of machine-language instructions stored in binary code which are executed by the processor to control all functions of the system: pump and valve motions, display and printer control, keyboard processing, data acquisition and parameter calculations.

Interface Switches
There are three switches in the cartridge compartment that provide machine status information to the microcomputer section:

- Home Switch (SW2), mounted near the cartridge valve actuator provides a reference point which corresponds to the "B" solution of the valve. This position is referred to in this manual as the "Home" position. Other positions of the valve actuator are referenced to this position.
- Cartridge Enable Switch (SW3), a large "micro" switch with a long actuator arm is mounted on the interior wall of the cartridge compartment at the top and is actuated when a cartridge is installed.
- Door Lock Switch (SW1), a small switch mounted at the top of the door frame is actuated when the door latch is closed. SW1 and SW3 are connected so that a "New Cartridge is In" signal is sent to the microcomputer when a cartridge is installed and the door is closed.

4.3 DESCRIPTION OF MAJOR GEM STAT SYSTEMS

This section describes the function of the various systems that operate simultaneously during routine operation of the GEM Stat.

Sensing Systems

Hematocrit
This sensor utilizes two electrodes that form a conductive cell. There is a direct relationship between the electrical conductivity of blood and the concentration of red blood cells in the sample. During operation, a small 500Hz A-C current is passed across the electrodes, and the resulting potential difference is measured.

Calcium, Sodium, Potassium, Carbon Dioxide and pH
These electrode sensors are all fabricated in a like manner. The end of a small silver wire is exposed to the sample chamber and covered by one or more layers of specific polymers, doped to result in an ion-selective film. The resulting ion-selective electrode develops a potential between itself and a common which is

proportional to the ion concentration being measured. The response is logarithmic with respect to ion concentration, and is ideally 60 mV/decade for pH, sodium, potassium, and carbon dioxide; 30 mV/decade for calcium.

Calcium, sodium, potassium, and pH are measured with respect to the reference electrode which is an undoped electrode located downstream from the other electrodes such that it is in contact with a reference solution.

The carbon dioxide electrode is also sensitive to pH. Therefore, the reported value of CO_2 is a function of the pH and CO_2 sensor readings.

The ion-selective films present very high impedance's, on the order of $(10)^{12}$ Ohms. They must be buffered by ultra-low bias current amplifiers. Path lengths are kept as short as possible to prevent leakage and are shielded by buffer amplifiers which are contained in the heater block to minimize noise pickup.

Oxygen

This sensor utilizes a single polarographic electrode in which a current proportional to oxygen concentration flows as a result of the application of a polarizing voltage. Response is linear with respect to oxygen concentration.

During operation, the current is converted to a voltage by a transimpedance amplifier in the heater block. This is merely an operational amplifier. The inverting input connects to the electrode. A high-value feedback resistor develops a voltage drop proportional to loop current. The polarization voltage is applied to the non-inverting input of the amplifier. By op-amp action, this same voltage is forced to appear at the inverting input and therefore is applied to the electrode. This polarizing voltage must then be subtracted from the signal at the output to calculate the oxygen concentration.

Calibration System

A 1-Point Cal is conducted every 90 seconds of the active sampling mode. During each 1-Point Cal, Solution "B" is pumped across the electrodes and the performance of each sensor is automatically adjusted to the expected sensor response for the known Cal B value.

The 2-Point calibration (2-Point Cal.) determines the line used to predict an analyte value based on an electrical response for each sensor (except Hematocrit). A 2-Point Cal occurs directly after warmup, 20 minutes later, then every 60 minutes of the active sampling mode.

During each 2-Point Cal., solutions "A" and "B" are pumped separately across the electrodes and the slope for each sensor is calculated based on the known values of Cal A and Cal B solutions as listed in Table 4-1 and the measured electrical response for each sensor. Therefore, each 2-Point Cal. continually adjusts the prediction line (within predefined limits) to reflect any change in sensor response.

Every 2-Point Cal. slope is checked for skewness and change from the previous 2-Point Cal. If any of the slopes or slope changes are outside of a preset limit a sensor failure occurs. After a sensor failure occurs subsequent results for patient blood and QC samples are blanked out for the failed sensor and any derived values on both the display and printouts. Often the next 2-Point Cal. will readjust the slope and determine it to be within limits in which case the values will be reported again.

Analyte	CAL-A	CAL-B
pH	6.90	7.40
PO2 (mmHg)	0	185
PCO2 (mmHg)	65	35
Hct (%)	0	11
Na+ (mmol/L)	155	135
K+ (mmol/L)	2.0	6.0
iCa++ (mmol/L)	0.20	2.0

Table 4-1, CAL-A and CAL-B "preset" values

Isolated Analog Power System

The circuitry in the heater block and all the circuitry on the A-D Board in the electrode signal processing chain through the voltage-to-frequency converter are electrically and physically isolated from other parts of the system. All isolated circuitry is operated from an isolation transformer. The degree of isolation complies with the requirements of international safety standards.

Heater Block Thermal Control Loop

Two thermistors in the heater block sense electrode card and heater block temperature. They are connected in parallel, and indicate the average temperature of their respective sources. One thermistor is mounted in a spring-loaded silver disk and makes contact with the metal plate on the back of the electrode card. The other thermistor is embedded in the aluminum block. The spring-loaded thermistor responds quickly to electrode card temperature. When solutions or blood are pumped into the sensor chamber with a temperature less than 37^{o}C, the thermal control loop rapidly applies more power to the heater to raise the temperature to 37^{o}C. The other thermistor prevents large thermal overshooting in block temperature. Because the electrode card is surrounded by the heater block, the average temperature of the two thermistors stabilize quickly and become equal.

Processing and Internal Communication System

The microcomputer circuitry controls all functions of the system, performs parameter calculations, and facilitates interaction with the operator. A Rockwell 6502 microprocessor and support devices are used in a standard configuration with separate ROM, RAM, CPU, parallel I/O and serial I/O devices connected through common address and data busses. All communication between the microcomputer section and other parts of the system take place through the parallel I/O devices.

Fluid System

During operation, the 3-Way Cartridge Valve located in the cartridge is actuated by the Valve Motor (M1) in the instrument. The valve is positioned to select one of the two-calibration solutions or the sample inlet. A peristaltic pump (M2) moves solution or blood into the Sensor Chamber and eventually into the Waste Bag.

Pump System

The Pump Motor (M2) is a 24 VAC synchronous motor that rotates at 20 RPM. A signal on the A-D board operates the Power Supply Assembly which controls this pump motor. The pump is a peristaltic type system. A pump roller mounts to the motor shaft which operates against two lengths of exposed tubing on the cartridge . One tube connects the valve to the Sensor Chamber and the second tube connects the Reference bag solution through the backside of the electrodes. Both solutions are pumped into the waste bag.

A means to determine roller position is necessary because the roller must be stopped in a specific location. This is accomplished using an optical sensor that senses black stripes on the roller. The sensor is a retro-reflective type that uses an LED and light sensitive transistor. The output is routed to an input port of the processor. The roller is stopped when the sensor "sees" a transition from a black stripe and reflective metal. The output of the sensor is low in this condition, so a low logic level should be present whenever the pump is not running. The "Diagnostics" mode can be used to test this function. Refer to Chapter 6, "Functional Diagnostic Tests" for a detailed description of pump system diagnostics.

Valve Actuator System

Valve motor (M1) is a stepper motor fitted with a pawl (Valve Control Arm) that engages and drives the 3-Way Cartridge Valve.

This stepper motor is driven by a stepper drive circuit on the Power Supply Assembly. The pawl on the motor engages a mechanical "Home" switch (SW2) which provides a reference position from which other positions of the valve are found. This switch signal is routed to an input port of the processor. The reference, or "Home" position is the "B-Cal" solution position of the valve (10:00). The sample valve position is 120 degrees counter-clockwise (CCW) from the Home position (6:00) and the "A-Cal" solution position is 240 degrees CCW from this position (2:00).

CHAPTER 5; TROUBLE-SHOOTING

5.1 TROUBLE-SHOOTING SUMMARY

The purpose of this chapter is to advise the user and/or repair technician when diagnosing problems in the field. Sections 5.2 through 5.5 pertain to problems that require a service representative while Sections 5.6 through 5.8 pertain to problems the user might encounter.

Tools required for servicing are: DMM (Digital Multi-Meter) and basic tools needed for disassembly of the instrument, namely; Screw drivers, Allen wrenches and Nut drivers up to 1/2 inch (English units).

Trouble-Shooting is broken into problem/failure types. Namely:

- Section 5.2, Inoperative Instrument.
- Section 5.3, Printer
- Section 5.4, Keyboard
- Section 5.5, Heater Block Failure
- Section 5.6, Alpha/Numeric Display Error Messages
- Section 5.7, Sampling Problems
- Section 5.8, Calibration Problems/Failures
- Section 5.9, QC Problems/Failures
- Section 5.10, Miscellaneous Problems

Other Sections that are referenced throughout this Chapter are:

- Section 6.2, Basic Operation Test.
- Section 7.3, General Disassembly of the GEM Stat.
- Section 8.1, Electrical Schematic and Wiring Drawings.
- Section 9.2, Cleaning Procedures.

Before attempting any repair or diagnostics, the trouble-shooter should be familiar with the contents of these sections so they can be referenced as needed.

Notes:

There are many references to Cable and PCB "Pin" type connectors. Jx/Px is a Cable/PCB Connector where, "J" designates the cable, "P" designates the PCB connector, and "x" designates the connection number.

For trouble-shooting the Power Converter refer to Appendix 5.

In the process of trouble-shooting or disassembly, cleaning of any contaminated areas of the instrument should be done even if it is not specifically stated in the trouble-shooting or disassembly instructions!

After completion of any repair the Basic Operation Test (Section 6.2) must be performed.

5.2 INOPERATIVE INSTRUMENT

Instrument Inoperative: No Visible Power

Symptoms - Instrument is completely inoperative - With power on there is no fan or display operation.

Step 1 With the instrument unplugged, examine the power cord for damage. With an ohmmeter, check for continuity in each of the three power cord lines, Hot, Neutral, and Ground, from the plug to the molded socket end of the power cord.

Step 2 Inspect the plug at the rear panel of the instrument. Be certain all the prongs extend properly and have not been pushed back or out of the socket.

Step 3 Remove the cover. (Refer to figure 7-1.) On the inner Rear Panel, inspect the faston connectors at the line plug (P1), line filter (FL1) and breaker/switch (CB1) making sure they are completely pushed on and secure.

Step 4 Remove the A/D Insulator. Disconnect ribbon cables to A/D board and remove. (Refer to figure 7-2 & 7-3).

Step 5 Separate the rear panel by removing the left-hand rail rear screw and three (3) bottom rear panel screws. Pull the rear panel back and lay down enough to access TB2 on the rear panel and position to allow power to be applied without danger of shorting out main power. (Refer to figure 7-9).

Step 6 Connect AC voltmeter to TB2 - terminals 13 and 10. Plug in the AC line cord and turn power/breaker switch on. Line voltage should be measured. If line voltage is not measured, CB1 is defective or a connection between Plug (P1) and the terminal strip is defective. Replace and/or repair and reassemble the rear panel. (Refer to figure 7-9).

Step 7 Disconnect J1 from the Power Supply Board (refer to figure 7-7). Connect an AC voltmeter to cable connector J1 (from main transformer) pins 4 and 6. The measured voltage should be approximately 32 VAC. Next connect to J1 pins 7 and 9. Approximately 20 VAC should be measured. Next connect to J1 pins 9 and 8. Approximately 20 VAC should be measured. Next check the voltage at J1, between pins 3 and 5. This should be about 10 VAC. If any of these voltages are zero (0), the main transformer is defective or there is a broken connection at the J1 connector. Replace the main transformer. (Refer to figure 7-10).

Instrument Inoperative: Display Contains Scattered LED Segments

Symptoms - With power on, fan operates but only scattered segments are lit in display.

Step 1 Remove Cover to access Test Points (TP"x") on Power Supply Board (refer to Power supply PCB layout for TP"x" locations in Section 8.1).

Step 2 With power connected and switch on, measure power supply test points using a DC voltmeter. Use TP6 as the ground connection. The voltages should be as follows;

TP1 = +23.75 to +24.25 VDC
TP2 = +11.4 to +12.6 VDC
TP3 = -11.4 to -12.6 VDC
TP4 = +4.9 to +5.1 VDC
TP5 = +5.35 to +5.75 VDC

Step 3 If one or more of the voltages are not present, turn power off and check the PTC's on the power board at locations F1, F2, F3 and the fuse at F4. Using an ohmmeter, each should measure less than 10 ohms resistance. Replace any PTC or fuse that measure higher than 10 ohms (refer to Power Supply Section 8.1 for locations of F1, F2 F3 and F4).

Step 4 If the PTC's and fuse check good but one or more voltages are not present at the test points, the power supply board is defective and must be replaced (Refer to Chapter 7. for disassembly).

Alpha-Numeric Display Stays at, "INSERT CART"

Symptom -After inserting a new cartridge, closing and latching the door, the display stays at "INSERT CART".

Step 1 Leave Cartridge inserted and remove Cover. (Refer to figure 7-1).

Step 2 Check Cartridge Enable Switch (SW1), (Refer to figure 5-1 for location). Verify the cartridge is fully inserted. With any type of cartridge installed, use an ohmmeter to measure the resistance across the terminals of SW1. The meter should read 0 ohms. If not, the switch is open and should be replaced.

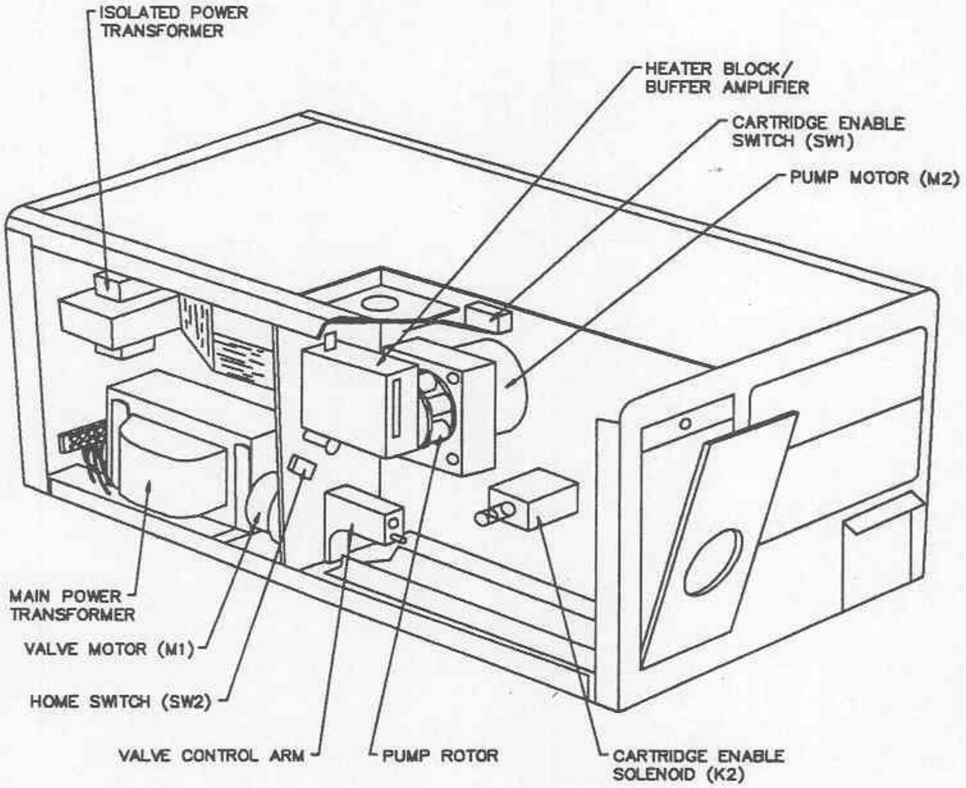

ISOLATED POWER TRANSFORMER
HEATER BLOCK/ BUFFER AMPLIFIER
CARTRIDGE ENABLE SWITCH (SW1)
PUMP MOTOR (M2)
MAIN POWER TRANSFORMER
VALVE MOTOR (M1)
HOME SWITCH (SW2)
VALVE CONTROL ARM
PUMP ROTOR
CARTRIDGE ENABLE SOLENOID (K2)

Fig. 5-1, Location of switch SW1

Step 3 Check the fastons on the switch, they should be soldered to the switch to prevent them from pulling off. Pull on the wires going into the fastons to insure they are not lose or broken. Replace the faston crimps if necessary.

Step 4 Verify that the Cartridge Enable Switch Actuator Arm is properly bent. When a cartridge is installed the arm should press against the switch closing the contacts. It may be necessary to carefully bend the spring slightly downward to insure the switch is fully closed.

Step 5 Check Door Lock Switch (SW3), (refer to figure 5-2). The switch makes contact when the door latch is full closed. Check the fastons on the switch, they should be soldered to the switch to prevent them from pulling off. Pull on the wires going into the fastons to insure they are not lose or broken. Replace the faston crimps if necessary.

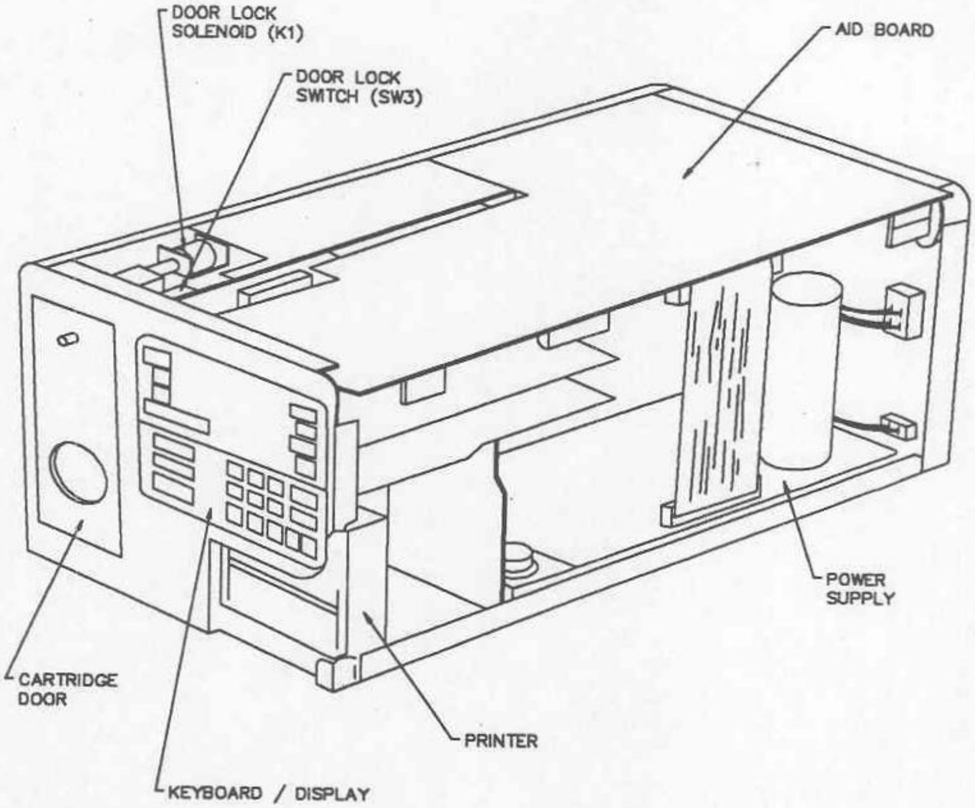


Fig 5-2, Location of switch SW3.

Step 6 With the door closed and completely latched, use an ohmmeter to measure the resistance across the terminals of SW3. The meter should read 0 ohms. If not, the switch is open and should be replaced.

Step 7 If both switches are operating remove the A/D board and install a new one. When reconnecting the cables be careful not to bend any pins or misalign any connector. Insert a cartridge, close the cartridge door and retest using the Basic Operation test and Cartridge test (refer to Chapter 6).

5.3 PRINTER PROBLEMS/FAILURE

NOTE:
Printer mechanism, especially the gears and rollers, are very delicate. Carefully remove paper with your fingers. Do not pry or force.

Printer Inoperative - No Printing or Paper Does Not Advance

Symptom - Printer will not print and paper will not advance when the paper feed key is pressed.

Step 1 Turn power off and remove paper from the printer. Press and hold the paper feed key while at the same time turning the power switch on. Release paper feed key.

Step 2 Add paper roll to the printer. Refer to figure 2-2 for more details. Make certain the paper is fed a minimum of one inch into the printer mechanism. If the printer begins to operate, the problem was a temporary logic lock up and is now corrected. If the paper will not feed continue with the next step.

Step 3 Power down the instrument and remove the cover.

Step 4 Remove connector J4 from the power supply board (refer to figure 7-4). Power up the instrument.

Step 5 Using a DC voltmeter, measure the voltage on the power supply board at P4 pins 2 and 3 using pin 4 as ground. Voltage should equal +24 VDC +/- 0.25V. Voltage from P4 pin 2 and 3, ground to pin 1, should be +5 VDC +/-0.1 VDC. If either of those voltages are incorrect, try adjusting RV2(5 VDC control) and RV1(24 VDC control) on the Power Supply PCB until +5 VDC and +24 VDC are obtained from the above test points. If either of the voltage levels cannot be corrected with this adjustment, the power supply board is defective and must be replaced (Refer to Chapter 7 for replacing the Power Supply Assembly). If voltages are correct, go to next step.

Step 6 Remove the printer power cable from P4 on the power supply board and the printer assembly. Check for continuity from end to end. Replace the cable if any opens are found.

Step 7 Turn instrument power off. Connect J4 from printer to P4 on the power supply board. Connect the DC voltmeter ground lead to TP6 and positive lead to TP1 on the power supply board. Turn power on. The voltage reading should be 24 VDC +/- 0.25 volts. Press the paper feed key. If the DC voltage drops below 23 VDC, the power supply board is suspect and should be replaced. If this measured voltage does not drop below 23 VDC or the same problem persists after replacing the power board, the printer is defective. Replace both the printer mechanism and the control circuit board as a set. (Refer to General Disassembly to remove the Printer and the Printer subassembly drawing both in Chapter 7).

Paper will not feed

Symptoms - No paper feeds during print out or by pressing paper feed key although it sounds like its working.

Step 1 Open printer door (on the side of the instrument) and see if the paper is jammed. Clear if required.

Step 2 Open front printer door. If paper has wound around roller inside the front printer door grab end of cut paper and pull out. If it does not pull out easily, carefully clear all paper and rethread roll. Do not pry of force mechanism.

Step 3 If this is not the problem, then go though the preceding procedure for "Printer Inoperative".

Printer feeds paper, but does not print.

Symptom - No printing on paper.

Step 1 Check if thermal printer paper was installed upside down or non-thermal paper was inserted. Install correct thermal paper with thermal sensitive side facing up.
Step 2 Replace printer if this is not the problem.

5.4 KEYBOARD PROBLEMS/FAILURE

Symptom - Keyboard has no response from some or all of the keys when pressed.

Step 1 Remove Cover (refer figure 7-1).
Step 2 Check the keypad connector at the A/D board, J5/P5 (refer figure 7-3). Make certain it is properly plugged into the A/D Board. (Not misaligned and no bent pins).
Step 3 Check the DC power supply voltages at the Power Supply Test Points following the steps in Section 5.2 for "Inoperative Instrument, Display Contains Scattered LED Segments".
Step 4 If correct voltages are present replace A/D Board with new one (refer to figures 7-2 and 7-3) and retest the keyboard as described in Section 6-2 under Functional Diagnostic Tests, "Keyboard". If the problem continues proceed to the next step.
Step 5 Turn the instrument off remove the Cover and unplug the keypad from the A/D board (J5/P5). Replace Membrane Keypad (# 610005). Turn the instrument on and repeat the Functional Diagnostic Test for "Keyboard."

5.5 HEATER BLOCK FAILURE

Symptom A - After processing a sample, HEATER BLK FAIL message is printed.

Problem - Instrument is being operated outside of acceptable ambient temperature range.

Step 1 Make sure there is six inches or more open space behind the GEM Stat for the fan to pull in air. If this might be a problem then move it so there is space behind the instrument. In addition, inspect the fan filter at the rear of the instrument to see if it is plugged with dust or lint. If so, then remove and clean it using soap and water. Be certain it is completely dry before reinstalling. See Section 9.2 for cleaning procedure. If the fan is not plugged or has been cleaned and the problem persists, continue to the next step.
Step 2 Verify fan operation. Turn instrument on. In a quiet environment you can hear the fan operating. With a piece of notebook paper held parallel to the fan filter at the rear of the instrument, the paper should be drawn to the fan filter. The air flow produced by the fan is from the outside of the instrument to the inside. If there is no fan operation, continue to the next step.

Step 3 Disassemble the instrument to the point where the rear panel can be safely laid back to allow access to TB2 with power applied (refer to Chapter 7). Turn power on and measure the AC voltage at TB2 terminals 8 and 9. If AC voltage is present, the fan is defective. If AC voltage is not present, check for secure connections to all the terminals on TB2 and check for the correct location of jumpers J1 and J2, (refer to Rear Panel Schematic figure 8-17 and Rear Panel Wiring Diagram figure 8-16). If no problem is found--follow the procedure in Section 5.2 for "Inoperative Instrument".

Symptom B - After processing a sample, the message "Heater Block Failed" is printed. All sensors fail calibration. When a new cartridge is inserted, the display counts down to "Warm up 0:00" and stops.

Problem - Heater block did not reach 37^{o} before processing.

Step 1 Disassemble GEM Stat to access the installed A/D Board with the Insulator Shield removed (refer to Chapter 7). Re-install the Right-hand Rail to support A/D Board. Turn power on and measure the AC voltage at the A/D Board connector P7 between pins 1 and 4. Approximately 18 VAC should be measured. If no voltage is measured, the Isolation Transformer is defective--remove and replace.

Step 2 Measure the AC voltage at P7 pin 3 to both sides of the PTC device at F1. If voltage is not present at both sides, the PTC is defective and should be replaced, (refer to figure 8-4, A/D Board PCB layout).

Step 3 Measure the AC voltage at the A/D Board connector P1 pins 4 and 8. If the instrument is cold, AC voltage will be present when first turned on. If the instrument is warm, the voltage should cycle on and off at approximately 30 second intervals. If this AC voltage is not present or does not cycle, the A/D board is defective. Turn power off and replace A/D Board.

Step 4 Disconnect the Heater Block Connector J1 from the A/D Board. With an ohmmeter, measure the resistance between pins 8 and 4 on J1. Resistance should be approximately 10 ohms. If infinite resistance is measured, the heater block is defective. Replace and perform functional diagnostic test.

5.6 ALPHA-NUMERIC DISPLAY ERROR MESSAGES

CRC FAILED

This message indicates a processor fault occurred when self testing (usually during power on). Try turning the power OFF then ON to rerun the self test. If same message appears replace the A/D Board.

RAM FAILED

Symptom - The message "RAM FAILED" is displayed after self test (usually during initial power up or after a power fail condition).

Step 1 Using a DMM check the Power Supply voltage on TP4 using TP6 as ground. Voltage at TP4 should be +5 VDC +/- 0.1 VDC. If not, try adjusting to +5 volts using RV2 on the power supply board, (refer to Power Supply, Section 8-1).
Step 2 Check the mounting screws on the 5 volt regulator U4. If they are loose the voltage could possibly drop below 5 VDC.
Step 3 Check all the cables to the power supply board and A/D board for proper connection--No bent pins or misaligned connectors, and all the "Ears" are locked.
Step 4 Replace RAM chip (U35, MSS # 900005) on the A/D board. Using a small bladed screw driver, carefully remove the RAM chip and replace it with a new one. (NOTE: The end marked with notch is pin 1).
Step 5 If "RAM FAILED" messages still appear replace the entire A/D board (MSS # 500027). After RAM chip is installed Run Basic Operation Tests (refer to Section 6.2).

SAMPLE ERROR

Problem - Parameter readings indicate that air was aspirated with the sample.

Step 1 Check that the GEM Sampler tube is inserted to the black line (refer to Section 3.2).
Step 2 Rerun sample being sure to hold the blood dispensing device in position until the display changes to "PROCESS".

VALVE FAILED (Also appears on printout if paper is installed)

Problem - Occurs whenever the Valve Control Arm rotates to SW2 in order to "Home the valve" but switch SW2 never closes. During normal operation the Control Arm rotates clockwise until SW2 closes then rotates counterclockwise to the 6:00 position thus setting the valve position.

Step 1 Open the Cartridge Door and remove the cartridge if present. Turn power off. Remove the cover or look inside cartridge compartment to observe Valve Control Arm.

Step 2 Rotate the Valve Control Arm to the 6 o'clock position, by hand.

Step 3 Turn power on. When the message "PLEASE WAIT." appears in the display the Valve Control Arm should rotate clockwise to the Home Switch (SW2) then counterclockwise back to the 6 O'clock position.

Step 4 If the Control Arm does not rotate, attempt to pull it from the motor shaft. If it pulls off, remove the cover and reinstall such that the Control Arm set screw tightens on the flattened section of the motor shaft.

Step 5 If the Control Arm rotates to the switch (SW2) but does not rotate counterclockwise, remove the cover, slide the insulating tubing back from the switch terminals. Using a jumper wire with an alligator clip at both ends, connect one end to the switch terminal. Move the actuator to the 6 o'clock position by hand. Turn power on. When the actuator begins moving clockwise, touch the second alligator clip end to the second switch terminal momentarily. The actuator should change directions to rotate counterclockwise. If it changes directions, the Home Switch (SW2) is defective--remove and replace it. If it does not change directions, replace the A/D Board and repeat this procedure.

5.7 SAMPLING PROBLEMS

Sample will not aspirate.

Step 1 Instrument not in "READY" mode. See Section 3.2 and wait until System is "READY."

Step 2 GEM Sampler clogged. Change Sampler.

Step 3 GEM Sampler not inserted completely into cartridge. Push Sampler until "stop line" is flush with cartridge.

Step 4 If problem still exists cartridge tubing is clogged--replace the cartridge.

Cartridge values do not compare with the lab.

Step 1 Determine if the lab sample has been mishandled or there is a time delay in transporting it to the lab. If so, correct the sample handling technique and eliminate time lag.

Step 2 Make sure EDTA tubes are not used as the blood collection device. If pre-heparinized syringes are used, make sure they have no greater than 25 USP units/ML of sodium or lithium heparin.

Step 3 Determine if the laboratory instrument is out of calibration. Request lab to calibrate their instrument (The GEM calibrates automatically; you will know if it is within calibration limits by reprinting the last calibration report).

Step 4 Determine if values from multiple cartridges (different lot numbers) do not compare with the lab by performing a correlation study. Conduct this study by analyzing 20 to 30 split-patient samples from the same syringe in both instruments. Perform split samples with the two instruments side by side.

Display reads, "OP000000000" and sample won't aspirate

Problem - Operator ID is required prior to analysis of blood sample. Mandatory Operator ID entry is a "Hidden Function" that can be enabled or disabled. Refer to Section 2.10, "Hidden Key Functions" which describes how to set the mandatory operator ID on or off.

Step 1. Enter the operator ID number, press ENTER, then process the sample.

Display reads, "PA000000000" and sample won't aspirate

Problem - Patient ID is required prior to analysis of blood sample. Mandatory Patient ID entry is a "Hidden Function" that can be enabled or disabled. Refer to Section 2.10, "Hidden Key Functions" which describes how to set the mandatory patient ID on or off.

Step 1. Enter the patient ID number and press ENTER, then run sample.

5.8 CALIBRATION PROBLEMS OR FAILURES

NOTE:

The GEM Stat has been designed so that if the performance of a sensor drifts beyond preset calibration slope limits, both patient and quality control results will be blanked-out for the failed analyte on all printouts. The patient value for the failed analyte will also be blanked out on the display. This section refers only to those situations where there are multiple calibration failures with multiple cartridges. Refer to Section 3.3 for further information on normal calibration failures.

Multiple Parameter Failures with Multiple Cartridges

Symptom - Multiple calibration failures occur with multiple cartridges. (Usually all parameters are failing calibration with the possible exception of PO_2).

Step 1 Check Power supply voltages using a DMM (refer to Section 5.2, Fan operates, scattered segment lights in display). If any of the voltages are bad, check the PTC devices on the Power supply Board . Replace PTC devices or PC board as required.

Step 2 Replace Heater Block (MSS# 450008). Run Basic Operation Tests (refer to Section 6.2).

Step 3 If problem still exists, replace A/D Board (Refer to figure 7-3).

5.9 QC PROBLEMS OR FAILURES

QC Values are not displayed on the instrument.

This is normal. QC values are never displayed to assure that they are not confused with patient values. Refer to the QC printout for QC test result values.

QC Printout Values are Blank followed by a question mark

Step 1 This indicates that the last two point calibration failed. Refer to section 3.3.
Step 2 The value was out of the preset high/low limits of the GEM Stat. Rerun QC test.

PO_2 failed QC (other values are within range).

Symptom - Measured PO_2 value is out of range. Other parameters are OK.

Step 1 Determine if GEM-Check was at room temperature when running sample. Refer to QC package insert, and calculate with temperature adjustment if required (PO_2 values in GEM-check are temperature sensitive), rerun test.

Multiple Parameter Values failed QC.

Symptom - QC printout indicates multiple parameters out of range.

Step 1 Check that proper ample was referenced.
Step 2 If the QC ampule was pulled away before display changed to "PROCESS", or if the GEM-Sampler was improperly inserted into the ampule, errors might have resulted. If so, refer to the QC package insert for instructions on properly aspirating the QC solution and rerun the QC test.
Step 3 QC sample was shaken too vigorously causing bubbles to be aspirated. Gently swirl the solution for 10 seconds prior to opening. Rerun test with new solution.

QC Values are displayed and reported on Patient Sample Printout

Symptom - After performing a QC test, the values are displayed and printed on a patient result printout rather than on a QC printout.

Either the QC solution was aspirated more than a minute after the display read "QC READY"--or--the correct SHIFT QC sequence was not followed. In either case, rerun the QC test.

Display reads, "BAD LOT NUM"

Invalid QC lot number has been entered. Refer to GEM Check or GEM Crit Check ample and type correct lot number then press ENTER key.

Display reads, "MUST DO QC "

A QC Test is required prior to analysis of blood sample. If mandatory QC test is "on" then at least one QC check must be performed before running the blood sample (refer to Section 2.10, "Hidden Key" Functions), to change the mandatory QC setting to on or off.

5.10 MISCELLANEOUS PROBLEMS

Instrument will not go into Standby.

Step 1 Determine if the instrument was performing another task when you attempted to start the STANDBY mode in which case retry.

Step 2 If the display momentarily shows "GOING 2 STBY," it will resume the current task and go into Standby when the task is completed. If it does not show this display, try to put it into Standby again.

Step 3 Cartridge Standby Life has been exceeded. Use existing active life by staying in READY mode. Run a Status report to confirm, (refer to Section 3.8). Replace the cartridge when signaled by Alpha-numeric display to "REMOVE CART".

Display reads, "NO GOOD DATA"

Data is unavailable to perform the requested task. For example, a printout of the last sample is requested before any samples have been analyzed. Enter necessary data and try again.

Display reads, "PLEASE WAIT"

Instrument is "busy" performing other functions. Wait until the display message changes to READY.

Display reads, "RECOVERING"

Power interruption has occurred. Instrument will recover automatically by rinsing sensors and/or performing a 2-PT CAL if required.

Display reads, "REMOVE CART" (remove cartridge)

One of the following has occurred, in any case the cartridge must be replaced!

- The door has been inadvertently opened.
- Cartridge life is expended.
- A power failure has occurred and lasted for over 30 minutes.
- Request to Remove Cart was selected through keypad entry.

CHAPTER 6; BASIC SYSTEM OPERATION TEST

6.1 PURPOSE

This procedure describes a method of testing the BASIC OPERATION of the GEM Stat where limited test equipment is available and subassembly repair is performed. This procedure can only be performed on a fully assembled GEM Stat.

Complete testing requires special test equipment, therefore these procedures do not constitute a complete test of safety or operation.

6.2 EQUIPMENT REQUIRED

Simulator cartridge (P/N 995003)
Power Adapter (9V DC @ 300ma)
Thermal Test cartridge (P/N 995029)
Dummy cartridge (P/N 995094)
3 1/2 DMM
Gem Stat basic test form

6.3 BASIC OPERATION TESTS

Power-up test.

1. Connect the unit to the power source appropriate for that model:

MODEL	FREQUENCY	VOLTAGE
4300	60 Hz	115 VAC
4400	60 Hz	100 VAC
4500	50 Hz	100 VAC
4600	50 Hz	220 VAC
4700	50 Hz	240 VAC
4300M*	50/60 Hz	115/230 VAC

* Set the voltage selector switch on the rear panel to the required voltage.

2. Turn the power ON. The alphanumeric display should show "SELF TEST" for about 10 seconds, then may display "WAIT CLOCK 1" and/or "WAIT CLOCK2" momentarily, then "PLEASE WAIT" for about 10 seconds. The display should then change to "INSERT CART".

3. Verify that the fan is operating quietly and that it is blowing into the instrument.

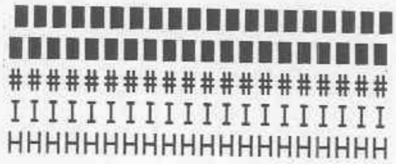
Real-Time Clock test.

Real-time Clock Test checks that the clock can in fact be set. Perform Clock test to confirm that time is being maintained.

Press SHIFT-MENU then repeatedly press the MENU key until the display shows "DATE/TIME?". Press ENTER. The date should be shown in the alphanumeric display. If U.S. format has been set, the display will show mm/dd/yy. If the International format has been set, the display will show dd/mm/yy. Correct the date if needed, then press ENTER. The time should now be displayed incrementing at one second intervals in 24 hour format hh/mm/ss. Correct the time if needed then press ENTER.

Printer Test.

Turn the power OFF. Press and hold the PAPER FEED keypad while turning the power on. The printer should produce a test printout. Allow at least 15 seconds for printing, then turn the power off. The test print out should appear as in Figure 6-1. All graphics should be solid black. Printer will continue to produce this pattern until power is turned off.



```
████████████████████
████████████████████
####################
IIIIIIIIIIIIIIIIIIII
HHHHHHHHHHHHHHHHHHHH
```

Fig. 6-1, Printout, Printer Test

Clock battery test.

Wait at least three minutes after the above Printer test (Power should be off). Turn the power on and check the date and time displays correctly by Pressing the SHIFT-MENU then repeatedly press the MENU key until the display shows "DATE/TIME? then press ENTER. Check the date then press ENTER, check the time and press ENTER again. If the time was just set in the "Real-Time Clock" test they should be correct. If date and time are still correct check pass on the test form, date and initial.

Power fail test

1. Making sure the "DUMMY" cartridge (P/N 995094) valve rotor is in the 6 O'clock position insert it or Install a jumper wire across the cartridge enable switch (SW1) (Refer to figure 5.1.). The only function of the cartridge or jumper is to put the GEM into the "Warmup" mode. The display will say "Close Door", close and latch the door. The display should now show "WARMUP XX:XX (where XX:XX is minutes:seconds) and begin counting down.

2. After approximately 2 minutes of counting down, turn the power off, leaving the jumper or cartridge in place.

3. Wait a minimum of 1 minute, then turn the power on. The display should read "SELF-TEST". (may show "WAIT CLOCK 1" and/or "WAIT CLOCK2" momentarily, then "RECOVERING"). A printout should be produced as shown in figure 6-2.

```
POWER FAILED AT
TIME: 6:58 PM
POWER RESTORED AT
TIME: 6:59 PM
```

Fig. 6-2, Power fail printout

4. Turn power off then remove the jumper or cartridge. Attach the printout to the test form and check the appropriate entry, date and initial.

Functional Diagnostics Tests

Enter the diagnostics mode by pressing these keys in sequence: SHIFT-IDENT-SHIFT-ENTER. The display should read "DIAG VSxxxxx". xxxxx = the software version installed in your instrument.

> NOTE:
> For quick reference to the keys used in performing these functional diagnostic tests, refer to Table 6-1.

1. Keyboard Test.

- Press ENTER keypad. The display should read "KEYBOARD TST".
- Press each key one at a time. The display should show the function of each primary keypad as it is pressed.
- Any Keypad pressed immediately following the SHIFT key must be pressed twice to display its function.
- To stop the test, press SHIFT then ENTER.

2. Display Test.

- Press the 8 keypad. All numeric displays should show an "8". The alphanumeric display should show all "8"s and the keyboard LED should be lit.
- Inspect the numeric displays. All digits should be matched in intensity and all segments should be properly displayed with no missing segments.
- Inspect the alphanumeric display. All characters should be matched in intensity.
- Press the 7 keypad. Beginning with the upper left digit in all blanks of displays, and sequencing from left to right and top to bottom, the following numeric characters will appear: **P, L, H, E, -, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0,** and **.** (decimal point). Make sure that for each digit in the blank, the characters are properly displayed with no missing or extra segments.
- The alphanumeric display should show the pattern "123* ABC* 456*" rotating right to left.
- The keyboard LED should illuminate periodically.
- Press any key to exit. If all keys function properly, check pass on the test form, date, and initial.

3. Cartridge Valve Actuator Test.

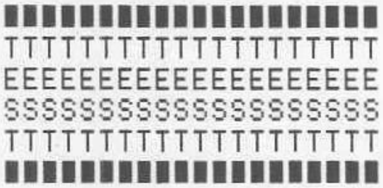
- Open the cartridge door to allow viewing of the Valve Actuator.
- Press the "1" keypad. The display should read "CART TO BSOL". The Valve Actuator should rotate clockwise and stop at the 10 o'clock position on the Home Switch (SW2).
- Press the "2" keypad. The display should read "CART TO ASOL". The Valve Actuator should rotate counter-clockwise and stop at the 2 o'clock position.
- Press the "3" keypad. The display should read "CART TO UNKN". The Valve Actuator should rotate clockwise to SW2, then counter-clockwise and stop at the 6 o'clock position.
- If the Valve Actuator rotates to all three position and displays the proper message, check pass on the test form, date and initial.

4. Pump Motor Speed Test.

- Press the SAMPLE keypad. The pump motor should run clockwise. The display should show "*PUMP OK". It is acceptable for the display to read "PUMP FAST" or "PUMP SLOW" momentarily but not regularly.
- Press any key to stop the pump motor.
- If the PUMP MOTOR runs and the display shows "PUMP OK", check pass on the test form, date and initial.

5. Printer Test.

Press the SHIFT, then the PRINT keypad. A printout as shown in figure 6-3 should be produced.



```
████████████████████
TTTTTTTTTTTTTTTTTTTT
EEEEEEEEEEEEEEEEEEEE
SSSSSSSSSSSSSSSSSSSS
TTTTTTTTTTTTTTTTTTTT
████████████████████
```

Fig. 6-3, Printout diagnostic Print Test.

6. Thermal Test

- Insert the THERMAL TEST CARTRIDGE P/N 995029 and close the door. The cover must be in place for the thermal test. (**Note:** Check the resistance test limits on the side of the cartridge before inserting. Enter the MSS number of the THERMAL CARTRIDGE on the test form).

- Allow the THERMAL CARTRIDGE to stabilize for at least 15 minutes before taking any readings. (45 minutes if the GEM Stat was off before this test).

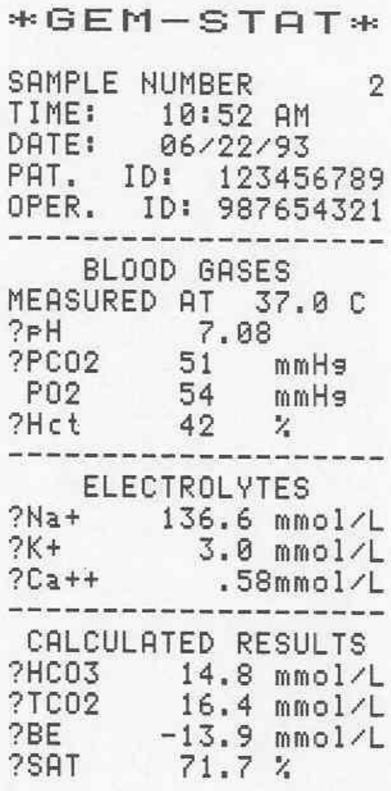
- Connect 3 1/2 digit digital multimeter to the jacks on the THERMAL TEST CARTRIDGE P/N 995029. Set the DMM to the 20K ohm scale.

- Observe the reading for 5 minutes. Record the cartridge MSS number and the high and low value on the GEM Stat Test Form. The high values must be within the limits marked on the test cartridge. The difference between the lowest and highest values must not exceed 12 ohms.

- Disconnect the ohmmeter and open the GEM Stat door and remove the cartridge.

7. Simulator Cartridge Test

- Before installing the SIMULATOR CARTRIDGE, (P/N 995003) check the rotor on the rear of the cartridge to be sure it is in the 6 O'clock position. Enter the MSS number of the SIMULATOR CARTRIDGE on the test form Fig 6-6.
- Turn the instrument off and then on to reset it. When the message "INSERT CART" appears, press SHIFT-IDENT-SHIFT-FIVE, before inserting the cartridge. Insert the SIMULATOR CARTRIDGE in the instrument and close the door, **NOTE:** (Cartridge must be inserted within 15 seconds). Instrument will display "WARMUP BLK". Connect the 9V power adopter to the SIMULATOR CARTRIDGE, and plug it into the appropriate power source.
- The display should count down from 7 minutes, or if 45 MIN is displayed, press SHIFT-IDENT-SHIFT-2 after the first 2 min., to shorten the warmup cycle. (**NOTE:** The time on the display will not change but the count down will be shortened to about 12 min.) When the display shows "READY 37.0C". Press SHIFT-IDENT-SHIFT-4 the display will momentarily show "HCT SAMP OFF". Press SHIFT-IDENT-SHIFT-5, the display will momentarily show "ERR PRINT ON". Press SHIFT-IDENT-SHIFT-6 to access the hidden menu options. Press the 8 key to scroll through the options to select "MAND ID ON (OFF)".Press the 9 key, if needed, to turn Mandatory ID ON. Press SHIFT-IDENT-SHIFT-CANCEL to go into the AUTO SAMPLING MODE. Press the SAMPLE key, the display will prompt you for PAT I.D. Press 123456789 then "ENTER". Then enter the instrument serial number and press "ENTER". Press SAMPLE again and the instrument will start Auto Sampling.
- The instrument will continue auto-sampling until 50 samples are completed or the instrument is turn off. See FIG 6-4 for a sample printout sheet. See form FIG 6-5 for the pass fail criteria for the instrument under test. This test may be terminated after the instrument has completed its second 2-PT calibration, about 1-1/2 hours, if no major repairs were performed. **NOTE:** If the A/D Board or the Heater Block were replaced the full 50 samples must be run.
- Instrument passes if all samples are in tolerance. Remove the SIMULATOR CARTRIDGE. Check pass on the test form, date and initial.



```
*GEM-STAT*

SAMPLE NUMBER       2
TIME:    10:52 AM
DATE:    06/22/93
PAT.  ID:  123456789
OPER.  ID: 987654321
--------------------
    BLOOD GASES
MEASURED AT  37.0 C
?pH          7.08
?PCO2      51    mmHg
 PO2       54    mmHg
?Hct       42    %
--------------------
    ELECTROLYTES
?Na+     136.6 mmol/L
?K+        3.0 mmol/L
?Ca++      .58mmol/L
--------------------
 CALCULATED RESULTS
?HCO3      14.8 mmol/L
?TCO2      16.4 mmol/L
?BE       -13.9 mmol/L
?SAT       71.7 %
```

Fig. 6-4, Printout, Simulated auto sample test

NOTES:

1. Sample number must be "1" for the first printout, "2" for the second printout, etc.
2. Time and Date must be correct for each printout.
3. PAT ID. must be "123456789".
4. OPER. ID. must be instrument serial #.
5. Values for pH, CO2, PO2, Hct, Na, K, and Ca must be within limits shown on Fig. 6-5
6. The SIMULATOR CARTRIDGE generates voltages that are higher than normal electrode voltages.

GEM Stat

ACCEPTABLE LIMITS FOR 995003 TEST CARTRIDGE

SAMPLE	LOW	HIGH	
BLOOD GASES			
PH	7.06	7.09	
PC02	49	52	mmHG
P02	50	58	mmHG
HCT	41	44	%
ELECTROLYTES			
Na+	135	138	mmol/L
K+	2.8	3.1	mmol/L
Ca++	.56	.60	mmol/L

NOTE: Results were taken from Test Form **DF 095** dated 01-30-1991.

Fig. 6-5 Simulated sample limits

Diagnostic Keypad Definitions

To access the Diagnostics Key Functions press SHIFT-IDENT-SHIFT-ENTER. The displays responds with "DIAG VS xxxxxx ("x's = the software Version). Once in this mode, the keyboard is redefined as follows:

Keypad	Function
0	Not Used.
1	Move Cartridge Valve Control Arm to Cal B Position.
2	Move Cartridge Valve Control Arm to Cal A Position.
3	Move Cartridge Valve Control Arm to SW2 then back to 6:00 Position. Display reads "CART TO UNKN".
4	Index Pump Roller.
5	Digitize all channels, print and transmit in same format as normal raw count printout.
6	Enable/Disable Cartridge Enable Solenoid (K2).
7	Dynamic display test: Each numeric and alphanumeric display is cycled through all possible characters.
8	Static display test: All "8"s in numeric displays. All "*"s in alphanumeric display.
9	Not Used.
ENTER	Keyboard Test: The function of any key pressed with the exception of the Paper Feed key is shown in the alphanumeric display. To stop test press SHIFT-ENTER.
SAMPLE	Causes pump to run continuously.
IDENT	Causes pump to run for one minute.
CANCEL	Enable/Disable Door Lock Solenoid (K1).
SHIFT-PRINT	Generates printer test pattern as shown in figure 6-3.
SHIFT-5	Exits diagnostic program and resets instrument (like power on).

Table 6-1, Diagnostic Keypad Functions.

Test Form

GEM STAT Serial No.________

MALLINCKRODT SENSOR SYSTEM, INC.

GEM STAT BASIC TEST PROCEDURE TEST FORM

PROCEDURE	Pass	Fail	Date	Initials
BASIC OPERATION				
REAL TIME CLOCK				
PRINTER TEST				
CLOCK BATTERY TEST				
POWER FAIL TEST				
FUNCTIONAL TESTS				
SOFTWARE VER ____________				
KEYBOARD TEST				
DISPLAY TEST				
VALVE CARTRIDGE ACTUATOR TEST				
PUMP MOTOR SPEED TEST				
PRINTER TEST				
SIMULATOR TEST MSS #__________				
THERMAL TEST MSS #__________				

HIGH VALUE ________

LOW VALUE ________

Fig. 6-6 Test result form

Chapter 7; Mechanical Disassembly

7.1 OVERVIEW

GEM Stat construction utilizes standard screw-type hardware for ease of reassembly. The reassembly procedure is a simple reverse of the disassembly unless noted otherwise. Be careful to maintain proper cable placement.

This chapter is organized as follows:

- Section 7.3, General Disassembly. Provides instructions on how to disassemble the whole instrument into major subassemblies.
- Section 7.4, Major Subassemblies. Shows an explosion view of each major subassembly that was removed in the General Disassembly.
- Section 7.5, Parts List. Contains a complete parts list of each item in the GEM Stat instrument.

Note
Electronic component parts are listed
with their PCB layout drawings in Chapter 8.

Note:
For drawings and information on Power Converter refer to Appendix 5.

Note:
In the process of trouble-shooting or disassembly, cleaning of any contaminated areas of the instrument should be done even if it is not specifically stated. Refer to Chapter 9, Cleaning Procedures

Warning

To avoid electrical shock, disconnect the
AC power cord before starting any disassembly.

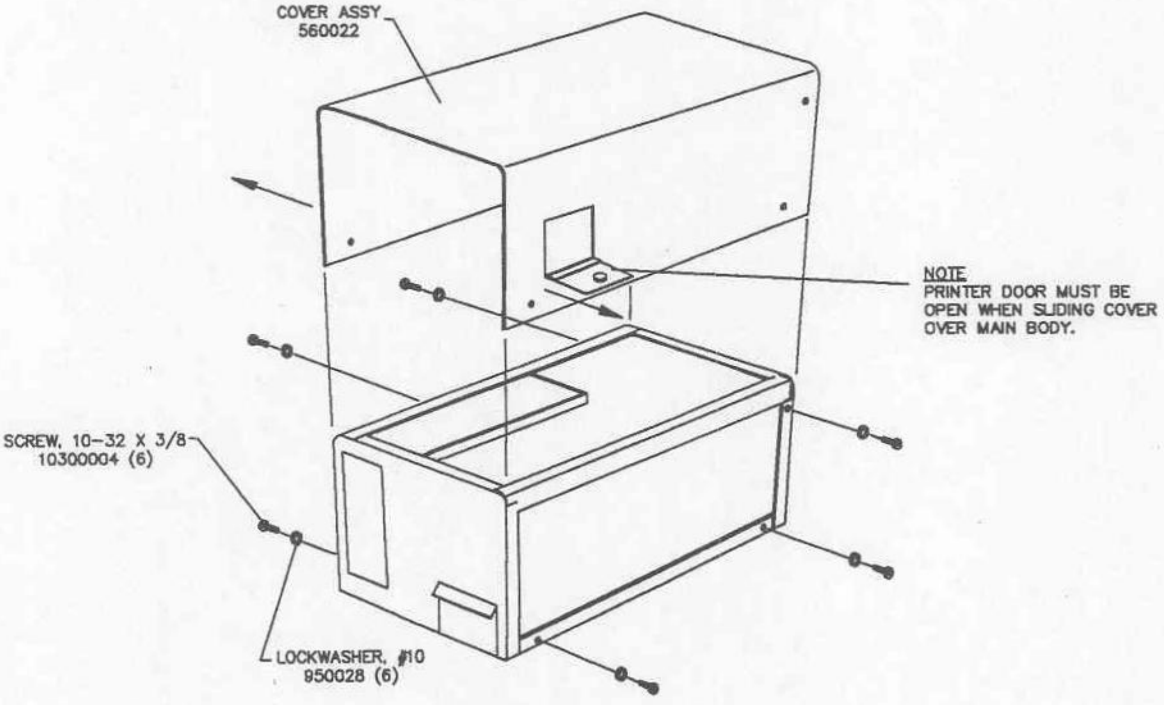
7.2 TOOLS REQUIRED FOR DISASSEMBLY

Only standard tools are required for complete disassembly of the GEM Stat. They include: Screw drivers (Phillips and Slot head), Allen wrench set, and a set of Nut drivers and/or Sockets and/or Wrenches (1/4 - 1/2 inch).

7.3 GENERAL DISASSEMBLY PROCEDURE

1. Remove the Cover Assembly (560022). Refer to figure 7-1.

- Unplug Instrument.
- Remove six cover screws (part number 10300004).
- Open side printer door.
- Pull both lower front corners of the Cover outward while lifting up the front then the rear.



NOTE
PRINTER DOOR MUST BE OPEN WHEN SLIDING COVER OVER MAIN BODY.

Fig 7-1; Removing the Cover Assembly.

2. Remove the A/D Board Insulator (69505). Refer to figure 7-2.
    - Remove Right-hand Rail by removing the front side screw (1014001), the rear screw (10290003), and pulling the rear end of the Rail away from the instrument then slide it off in the direction of the rear panel.
    - Remove the A/D Board Insulator (695058) by pulling it out the right side of the instrument.

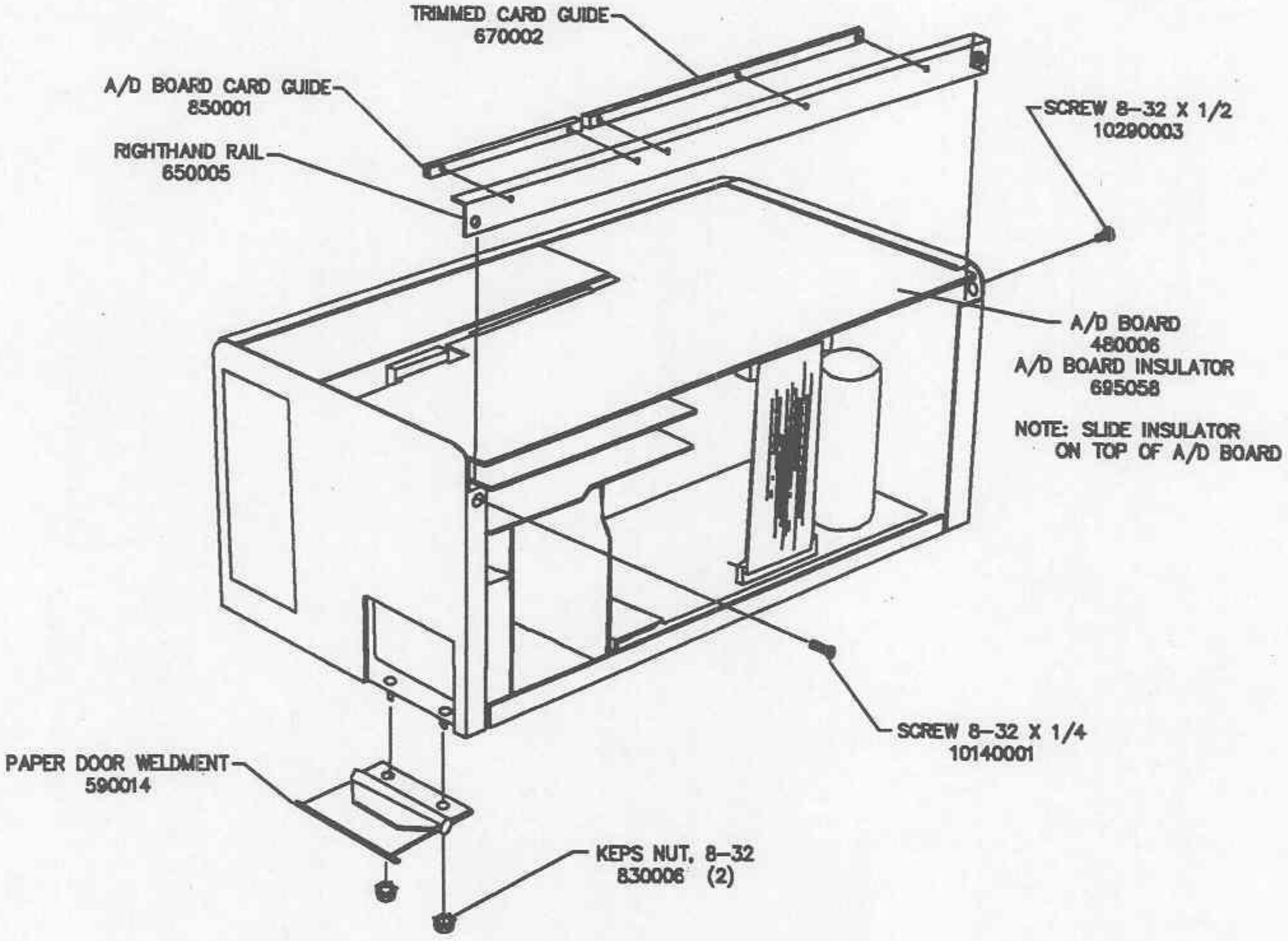

TRIMMED CARD GUIDE
670002
A/D BOARD CARD GUIDE
850001
RIGHTHAND RAIL
650005
SCREW 8-32 X 1/2
10290003
A/D BOARD
480006
A/D BOARD INSULATOR
695058
NOTE: SLIDE INSULATOR ON TOP OF A/D BOARD
SCREW 8-32 X 1/4
10140001
PAPER DOOR WELDMENT
590014
KEPS NUT, 8-32
830006 (2)

Fig. 7-2; Removing the A/D board insulator.

Note:
A/D Board Insulator lays on top of A/D Board. It acts as an electrical insulator.

3. Remove the A/D Board (48006). Refer to figure 7-3.

- Disconnect the six A/D board connections .
- Slide the A/D Board out the right side of the instrument. (Right side looking at the front).

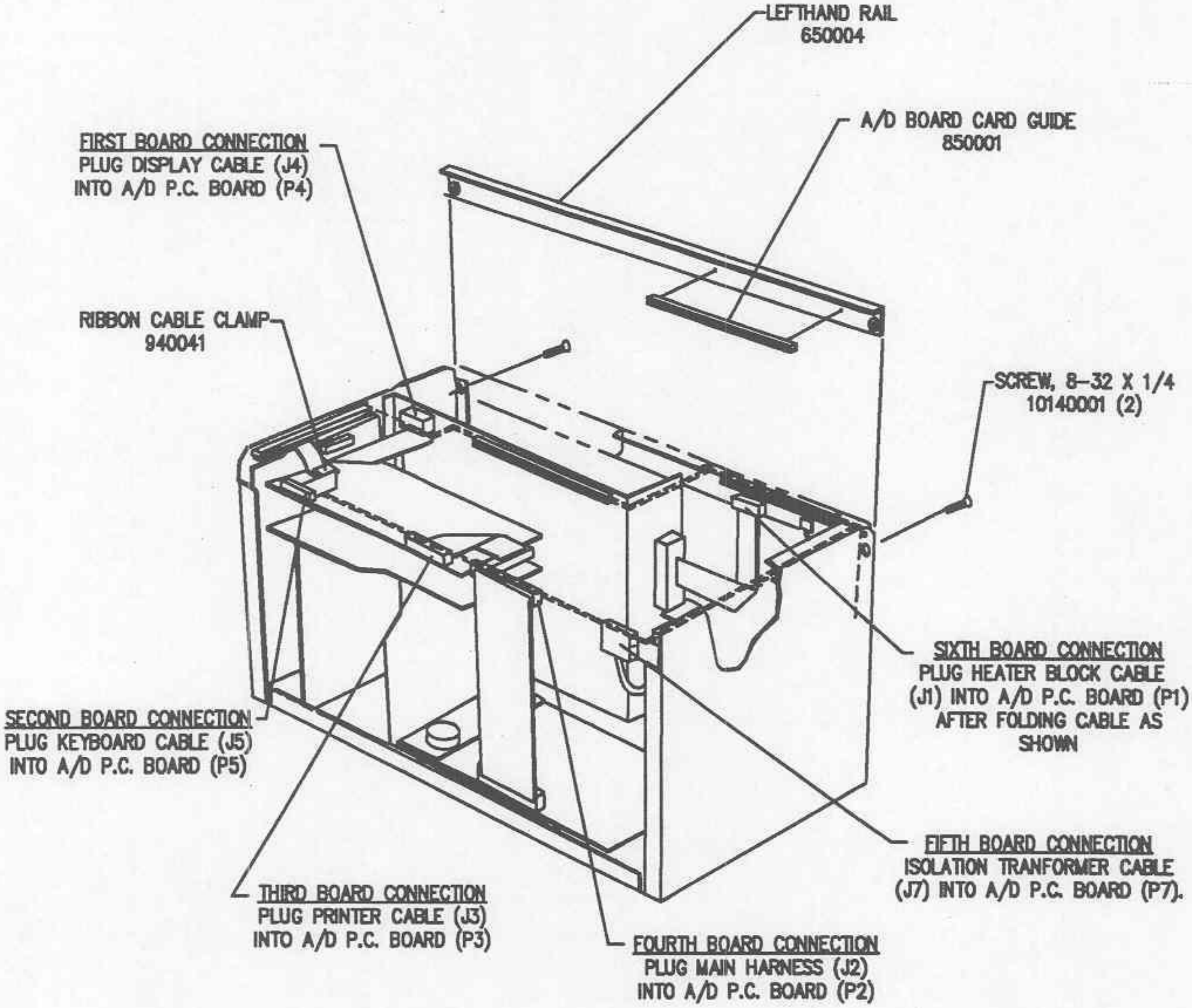

LEFTHAND RAIL
650004
A/D BOARD CARD GUIDE
850001
FIRST BOARD CONNECTION
PLUG DISPLAY CABLE (J4)
INTO A/D P.C. BOARD (P4)
RIBBON CABLE CLAMP
940041
SCREW, 8-32 X 1/4
10140001 (2)
SIXTH BOARD CONNECTION
PLUG HEATER BLOCK CABLE
(J1) INTO A/D P.C. BOARD (P1)
AFTER FOLDING CABLE AS
SHOWN
SECOND BOARD CONNECTION
PLUG KEYBOARD CABLE (J5)
INTO A/D P.C. BOARD (P5)
FIFTH BOARD CONNECTION
ISOLATION TRANFORMER CABLE
(J7) INTO A/D P.C. BOARD (P7).
THIRD BOARD CONNECTION
PLUG PRINTER CABLE (J3)
INTO A/D P.C. BOARD (P3)
FOURTH BOARD CONNECTION
PLUG MAIN HARNESS (J2)
INTO A/D P.C. BOARD (P2)

Fig. 7-3; Removing the A/D board.

4. Remove the Printer Assembly (560003). Refer to figures 7-4 & 7-5.
    - Disconnect Printer power cable as shown.

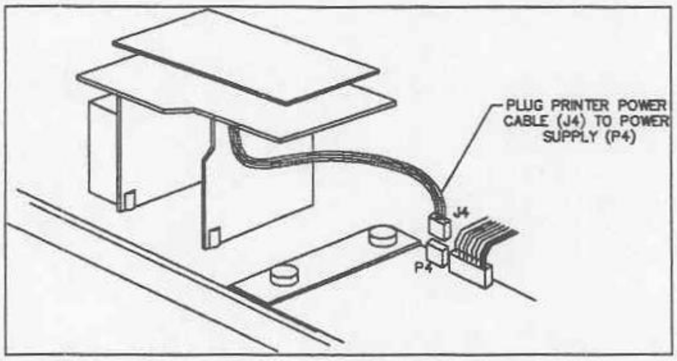

PLUG PRINTER POWER CABLE (J4) TO POWER SUPPLY (P4)
J4
P4

Fig. 7-4; Disconnect the Printer power cable

- Turn the instrument on its side so that the bottom is accessible.
- Remove the four screws (10290003) from underneath the instrument that secure the Printer to the chassis.

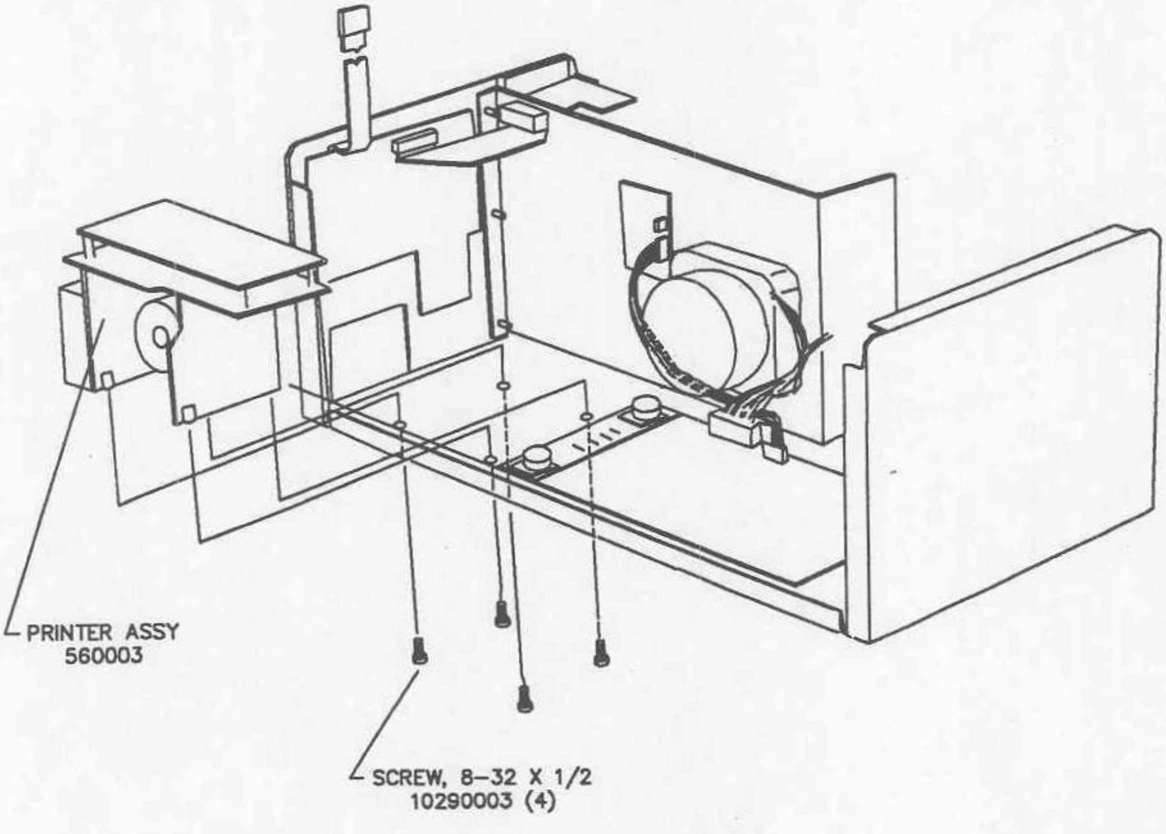

PRINTER ASSY
560003
SCREW, 8–32 X 1/2
10290003 (4)

Fig. 7-5; Removing the Printer.

5. Remove the Front and Inner Panel. (Refer to figure 7-6).

    - Disconnect the cables J3 & J6 from the Inner Panel to the Power Supply.
    - Turn the instrument on its side so that the bottom is accessible.
    - Remove the three screws (1029001) that secure the Front Panel to the Chassis and the two screws (1029001) that secure the Inner Panel to the Chassis.
    - Turn the instrument upright.
    - Remove the screws (10140001) that secure the Left-hand Rail (650004), see (figure 7-3).
    - Pull the Rail up and away from the instrument.

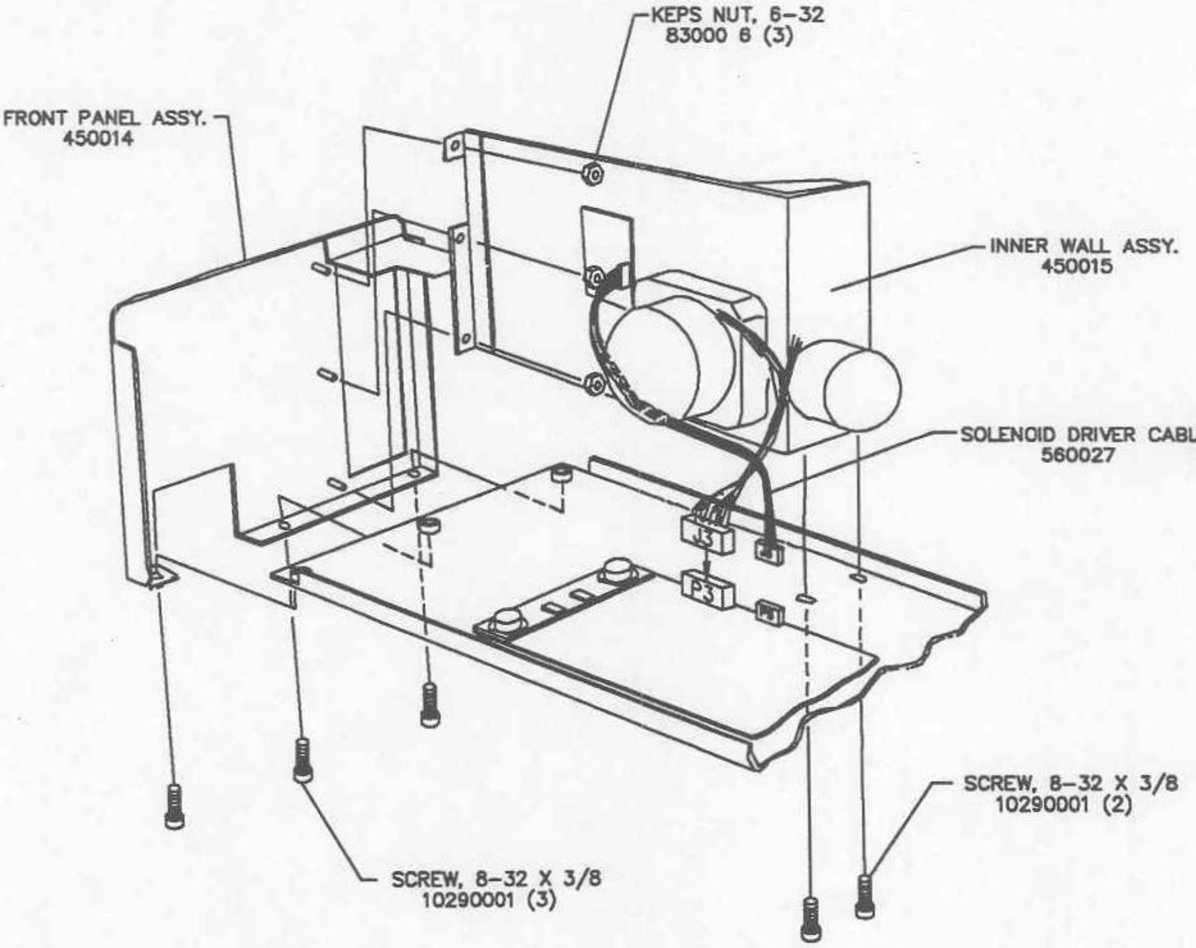

KEPS NUT, 6-32
83000 6 (3)
FRONT PANEL ASSY.
450014
INNER WALL ASSY.
450015
SOLENOID DRIVER CABL
560027
J3
P3
SCREW, 8-32 X 3/8
10290001 (2)
SCREW, 8-32 X 3/8
10290001 (3)

Fig. 7-6; Removing the Front and Inner Panel.

To disconnect the Front Panel from the Inner Panel.

- Disconnect the wires that attach to the Door lock Switch (SW3), the Door Lock Solenoid (K1) and the Cartridge Switch (SW1). (Refer to figure 8-10, for wiring).
- Remove the nuts (830006) that secure the Inner Panel to the front panel.

6. Remove the Power Supply. (Refer to figures 7-7 and 7-8)
   - Disconnect main transformer cable and main wire harness from power supply board.

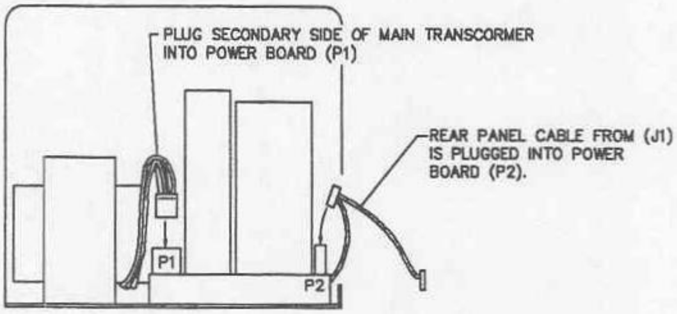

PLUG SECONDARY SIDE OF MAIN TRANSCORMER INTO POWER BOARD (P1)
REAR PANEL CABLE FROM (J1) IS PLUGGED INTO POWER BOARD (P2).
P1
P2

Fig. 7-7; Disconnecting the Main Transformer Cable and Main Wire Harness from Power Supply.

   - Remove six screws (10290001) that secure the Power Supply Board to the Chassis . Refer to figure 7-8.
   - Remove screw (10290005) and nut (830008) from the bridge rectifier.
   - Lift Power Supply up and out.

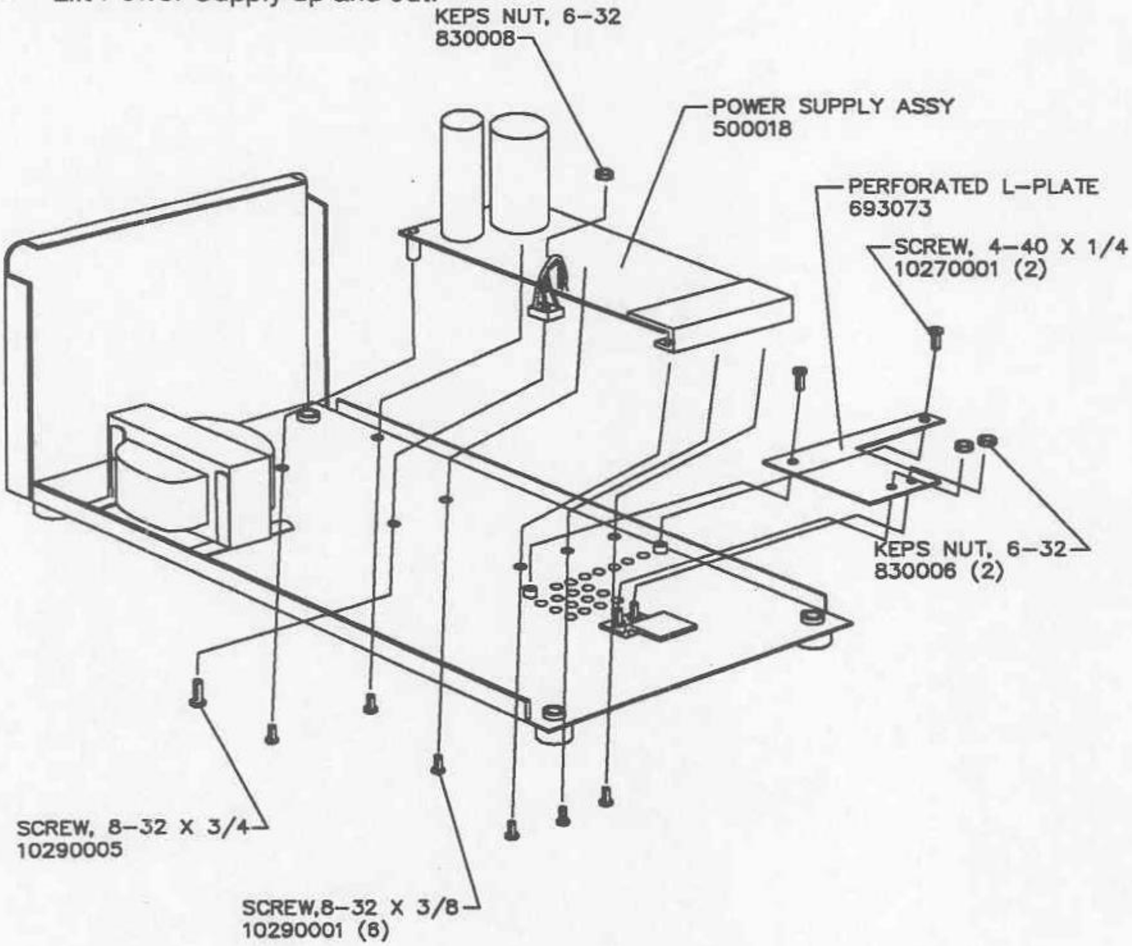

KEPS NUT, 6-32
830008
POWER SUPPLY ASSY
500018
PERFORATED L-PLATE
693073
SCREW, 4-40 X 1/4
10270001 (2)
KEPS NUT, 6-32
830006 (2)
SCREW, 8-32 X 3/4
10290005
SCREW,8-32 X 3/8
10290001 (6)

Fig. 7-8, Removing the Power Supply.

7. Remove the Rear Panel. Refer to figure 7-9.

    - Remove three screws (1029007) that secure the rear panel to the chassis.
    - Lean Rear panel back as shown in the figure.
    - Disconnect wires to Terminal Block "2" (TB2).
    - Disconnect Ground Strap from the Rear Panel by pulling it off the connector.
    - Pull Main Harness out of the ribbon cable mounts attached to the chassis.

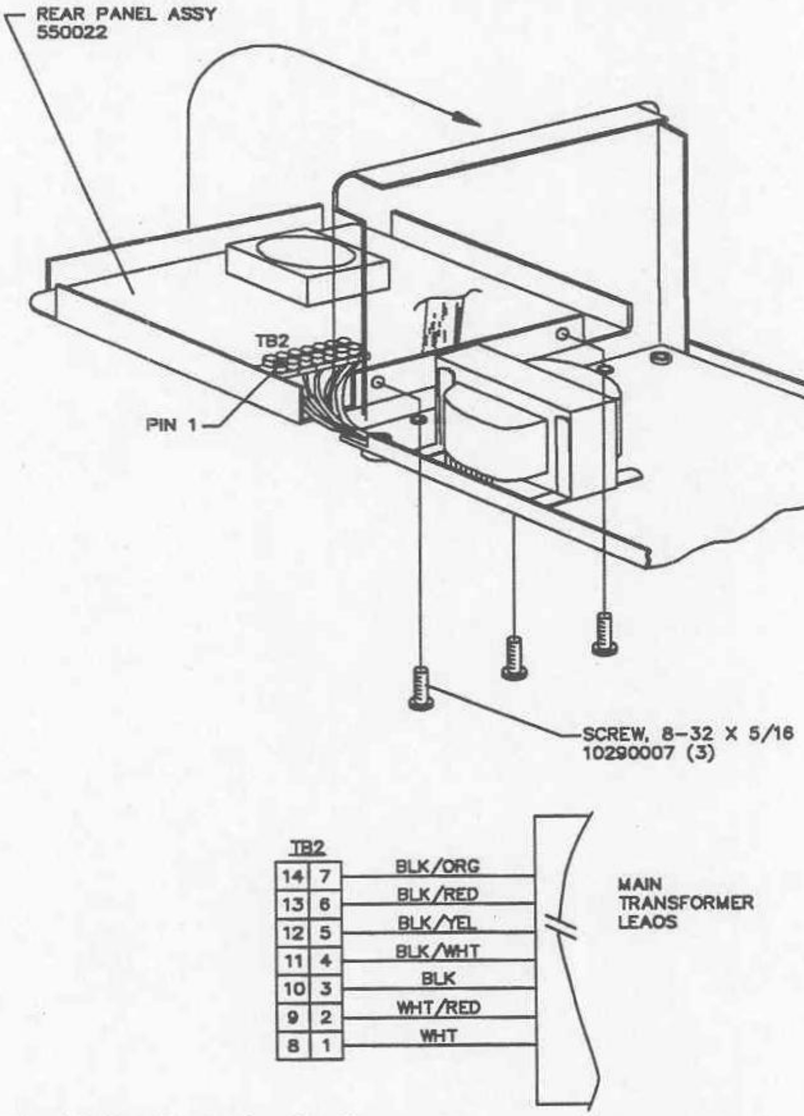

REAR PANEL ASSY
550022
TB2
PIN 1
SCREW, 8-32 X 5/16
10290007 (3)
TB2
14
7
13
6
12
5
11
4
10
3
9
2
8
1
BLK/ORG
BLK/RED
BLK/YEL
BLK/WHT
BLK
WHT/RED
WHT
MAIN
TRANSFORMER
LEAOS

Fig. 7-9, Removing the Rear Panel.

Notes for reassembly:

1. Refer to the "Rear Panel Wiring Diagram", (fig. 8-16) for rewiring the Main Transformer to TB2.
2. Make sure the six inch tape along the Chassis flange is intact. If not, replace it.
3. The main harness ribbon cable folds over itself when making the 90 degree bend.
4. The lip on the rear panel goes under the chassis.

8. Remove the Main Transformer (550007). Refer to figure 7-10.
    - Remove the four screws (10300001) and nuts (830010) that secure the Transformer to the Chassis.
    - Lift the transformer up and away from the Chassis.

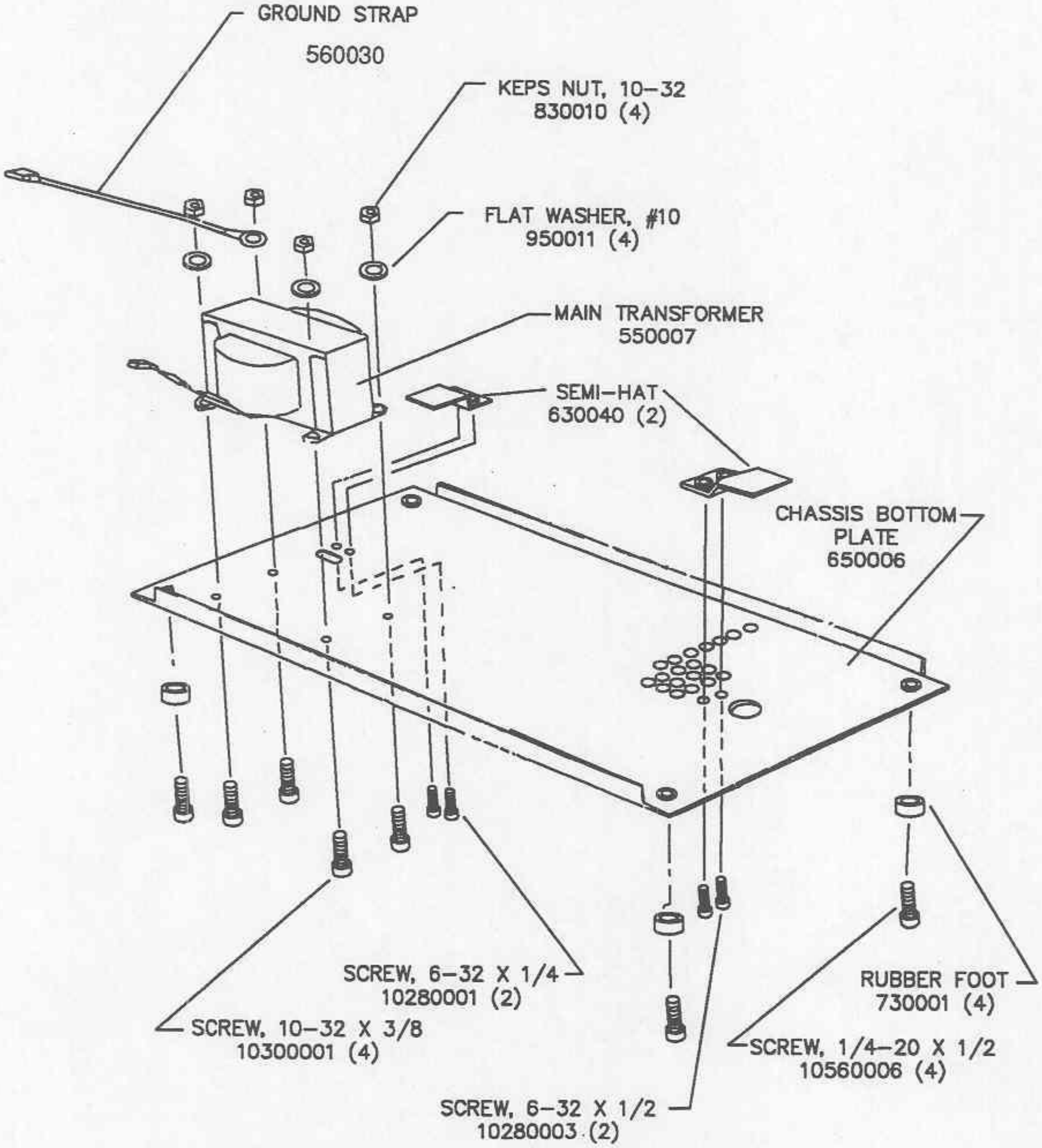

GROUND STRAP
560030
KEPS NUT, 10-32
830010 (4)
FLAT WASHER, #10
950011 (4)
MAIN TRANSFORMER
550007
SEMI-HAT
630040 (2)
CHASSIS BOTTOM PLATE
650006
SCREW, 6-32 X 1/4
10280001 (2)
RUBBER FOOT
730001 (4)
SCREW, 10-32 X 3/8
10300001 (4)
SCREW, 1/4-20 X 1/2
10560006 (4)
SCREW, 6-32 X 1/2
10280003 (2)

Fig. 7-10; Removing the Main Transformer.

Notes for reassembly:

- Primary leads are tucked underneath the windings and next to the Chassis flange leading toward TB2.

7.4 MAJOR SUBASSEMBLY DIAGRAMS

Included in this section are the following drawings: Inner Panel Assembly; Front Panel Assembly, Rear Panel Assembly, Cover Assembly, Cartridge Door Assembly and Printer Assembly.

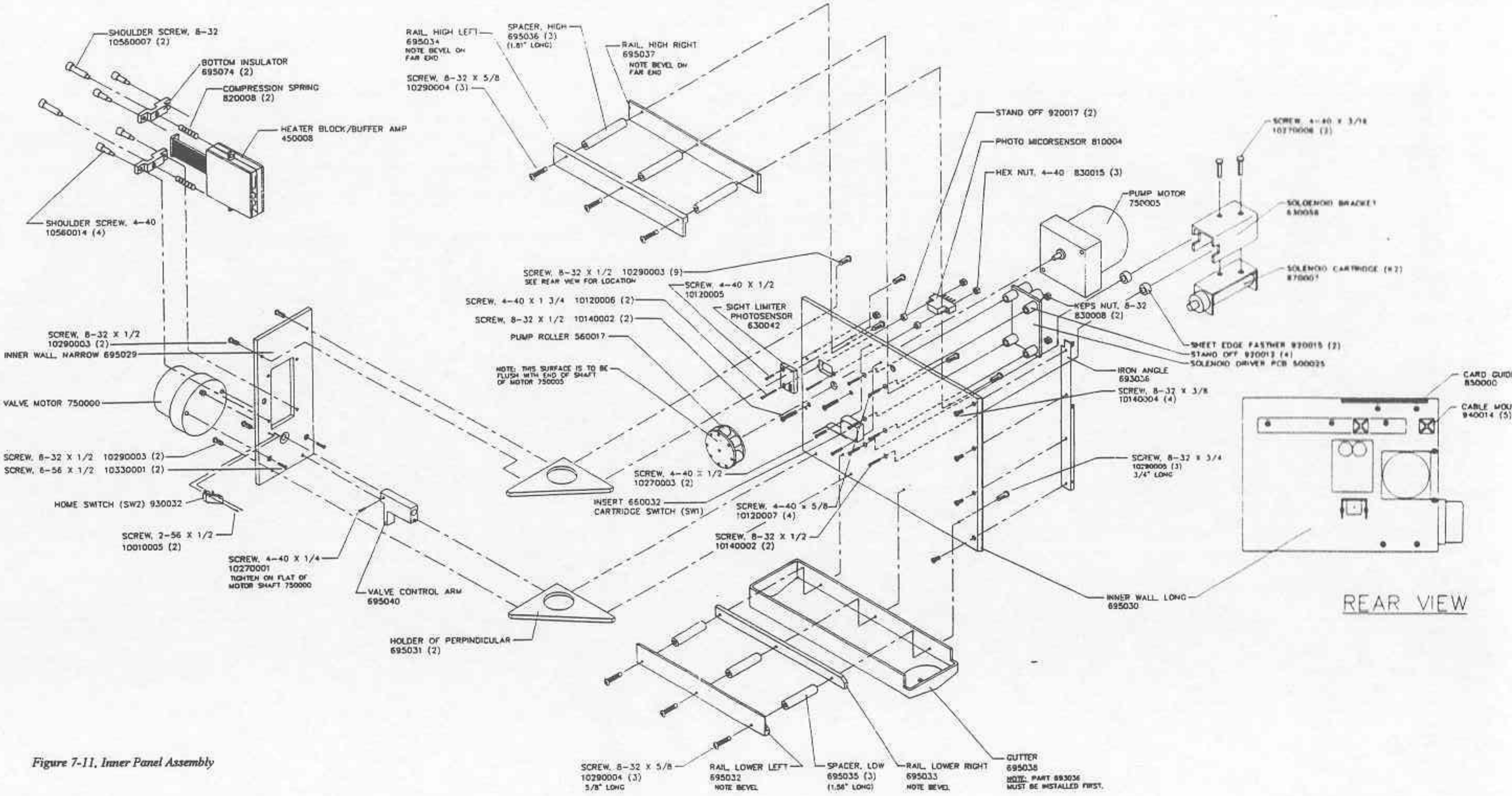

SHOULDER SCREW, 8-32
10560007 (2)
BOTTOM INSULATOR
695074 (2)
COMPRESSION SPRING
820008 (2)
HEATER BLOCK/BUFFER AMP
450008
SHOULDER SCREW, 4-40
10560014 (4)
RAIL, HIGH LEFT
695034
NOTE BEVEL ON
FAR END
SPACER, HIGH
695036 (3)
(1.81" LONG)
RAIL, HIGH RIGHT
695037
NOTE BEVEL ON
FAR END
SCREW, 8-32 X 5/8
10290004 (3)
STAND OFF 920017 (2)
PHOTO MICORSENSOR 810004
HEX NUT, 4-40 830015 (3)
PUMP MOTOR
750005
SCREW, 4-40 X 3/16
10270008 (2)
SOLOENOID BRACKET
630058
SOLENOID CARTRIDGE (#2)
870007
KEPS NUT, 8-32
830008 (2)
SHEET EDGE FASTNER 920015 (2)
STAND OFF 920013 (4)
SOLENOID DRIVER PCB 500025
IRON ANGLE
693036
SCREW, 8-32 X 3/8
10140004 (4)
SCREW, 8-32 X 3/4
10290005 (3)
3/4" LONG
CARD GUID
850000
CABLE MOU
940014 (5)
REAR VIEW
INNER WALL, LONG
695030
SCREW, 8-32 X 1/2 10290003 (9)
SEE REAR VIEW FOR LOCATION
SCREW, 4-40 X 1/2
10120005
SIGHT LIMITER
PHOTOSENSOR
630042
SCREW, 4-40 X 1 3/4 10120006 (2)
SCREW, 8-32 X 1/2 10140002 (2)
PUMP ROLLER 560017
NOTE: THIS SURFACE IS TO BE
FLUSH WITH END OF SHAFT
OF MOTOR 750005
SCREW, 4-40 X 1/2
10270003 (2)
INSERT 650032
CARTRIDGE SWITCH (SW1)
SCREW, 4-40 x 5/8
10120007 (4)
SCREW, 8-32 X 1/2
10140002 (2)
SCREW, 8-32 X 1/2
10290003 (2)
INNER WALL, NARROW 695029
VALVE MOTOR 750000
SCREW, 8-32 X 1/2 10290003 (2)
SCREW, 6-56 X 1/2 10330001 (2)
HOME SWITCH (SW2) 930032
SCREW, 2-56 X 1/2
10010005 (2)
SCREW, 4-40 X 1/4
10270001
TIGHTEN ON FLAT OF
MOTOR SHAFT 750000
VALVE CONTROL ARM
695040
HOLDER OF PERPINDICULAR
695031 (2)
SCREW, 8-32 X 5/8
10290004 (3)
5/8" LONG
RAIL, LOWER LEFT
695032
NOTE BEVEL
SPACER, LOW
695035 (3)
(1.56" LONG)
RAIL, LOWER RIGHT
695033
NOTE BEVEL
GUTTER
695038
NOTE: PART 693036
MUST BE INSTALLED FIRST.

Figure 7-11, Inner Panel Assembly

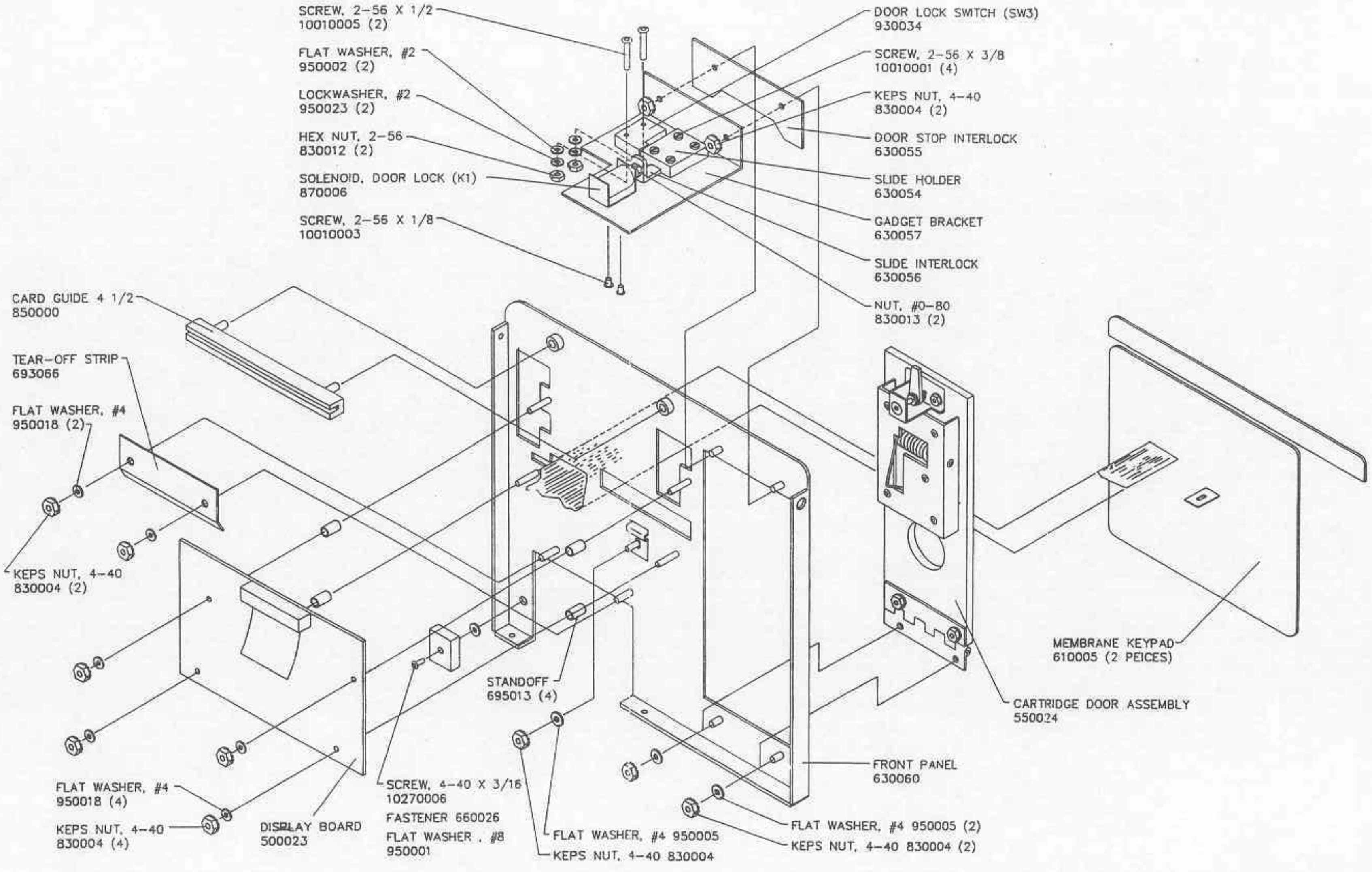

SCREW, 2-56 X 1/2
10010005 (2)
FLAT WASHER, #2
950002 (2)
LOCKWASHER, #2
950023 (2)
HEX NUT, 2-56
830012 (2)
SOLENOID, DOOR LOCK (K1)
870006
SCREW, 2-56 X 1/8
10010003
DOOR LOCK SWITCH (SW3)
930034
SCREW, 2-56 X 3/8
10010001 (4)
KEPS NUT, 4-40
830004 (2)
DOOR STOP INTERLOCK
630055
SLIDE HOLDER
630054
GADGET BRACKET
630057
SLIDE INTERLOCK
630056
NUT, #0-80
830013 (2)
CARD GUIDE 4 1/2
850000
TEAR-OFF STRIP
693066
FLAT WASHER, #4
950018 (2)
KEPS NUT, 4-40
830004 (2)
MEMBRANE KEYPAD
610005 (2 PEICES)
CARTRIDGE DOOR ASSEMBLY
550024
STANDOFF
695013 (4)
FRONT PANEL
630060
FLAT WASHER, #4
950018 (4)
KEPS NUT, 4-40
830004 (4)
DISPLAY BOARD
500023
SCREW, 4-40 X 3/16
10270006
FASTENER 660026
FLAT WASHER , #8
950001
FLAT WASHER, #4 950005
KEPS NUT, 4-40 830004
FLAT WASHER, #4 950005 (2)
KEPS NUT, 4-40 830004 (2)

Fig. 7-12, Front Panel Assembly

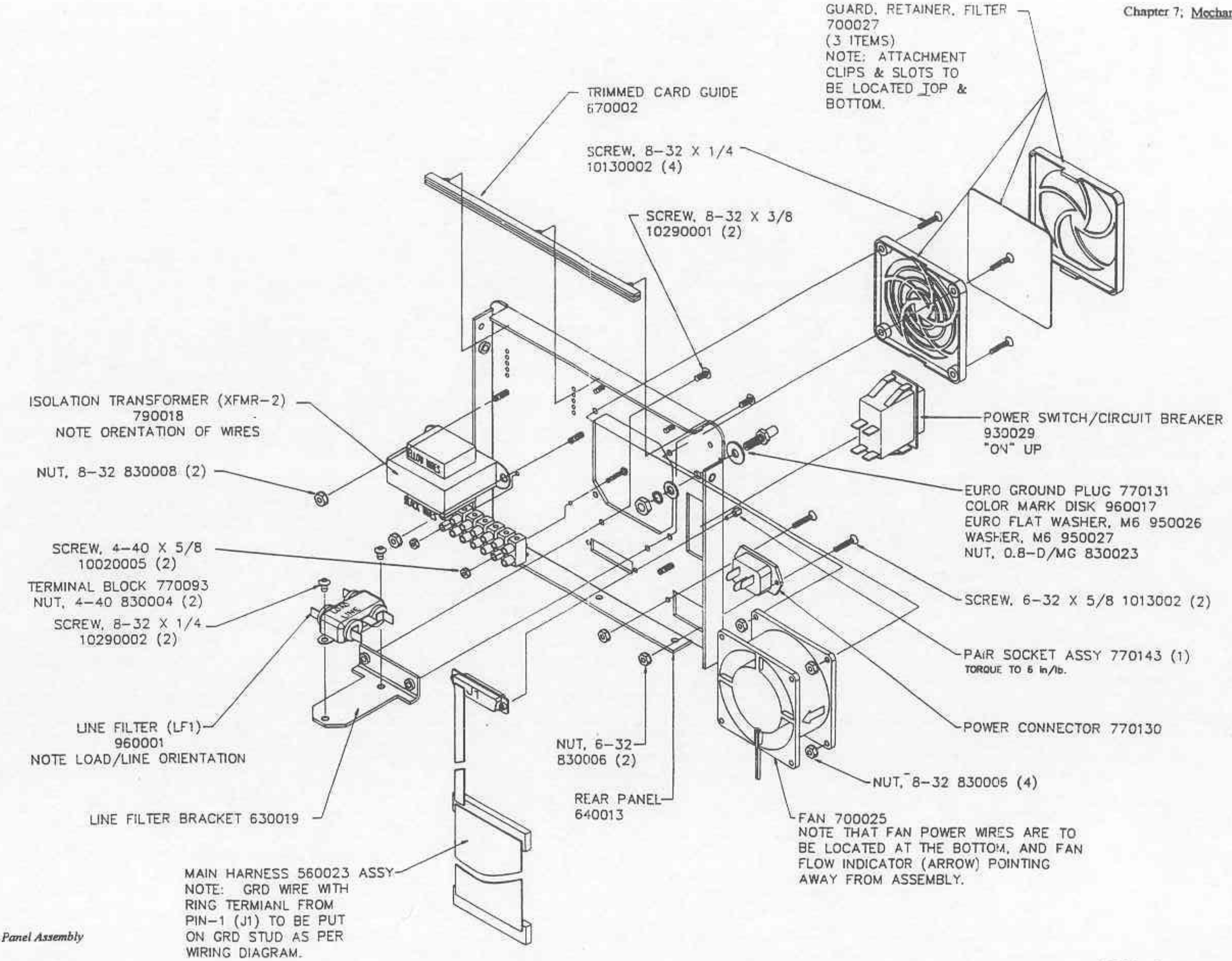

GUARD, RETAINER, FILTER
700027
(3 ITEMS)
NOTE: ATTACHMENT CLIPS & SLOTS TO BE LOCATED TOP & BOTTOM.
TRIMMED CARD GUIDE
670002
SCREW, 8-32 X 1/4
10130002 (4)
SCREW, 8-32 X 3/8
10290001 (2)
ISOLATION TRANSFORMER (XFMR-2)
790018
NOTE ORENTATION OF WIRES
NUT, 8-32 830008 (2)
SCREW, 4-40 X 5/8
10020005 (2)
TERMINAL BLOCK 770093
NUT, 4-40 830004 (2)
SCREW, 8-32 X 1/4
10290002 (2)
LINE FILTER (LF1)
960001
NOTE LOAD/LINE ORIENTATION
LINE FILTER BRACKET 630019
MAIN HARNESS 560023 ASSY
NOTE: GRD WIRE WITH RING TERMIANL FROM PIN-1 (J1) TO BE PUT ON GRD STUD AS PER WIRING DIAGRAM.
NUT, 6-32
830006 (2)
REAR PANEL
640013
POWER SWITCH/CIRCUIT BREAKER
930029
"ON" UP
EURO GROUND PLUG 770131
COLOR MARK DISK 960017
EURO FLAT WASHER, M6 950026
WASHER, M6 950027
NUT, 0.8-D/MG 830023
SCREW, 6-32 X 5/8 1013002 (2)
PAIR SOCKET ASSY 770143 (1)
TORQUE TO 6 in/lb.
POWER CONNECTOR 770130
NUT, 8-32 830006 (4)
FAN 700025
NOTE THAT FAN POWER WIRES ARE TO BE LOCATED AT THE BOTTOM, AND FAN FLOW INDICATOR (ARROW) POINTING AWAY FROM ASSEMBLY.
YELLOW WIRES
BLACK WIRES
LINE

Fig. 7-13, Rear Panel Assembly

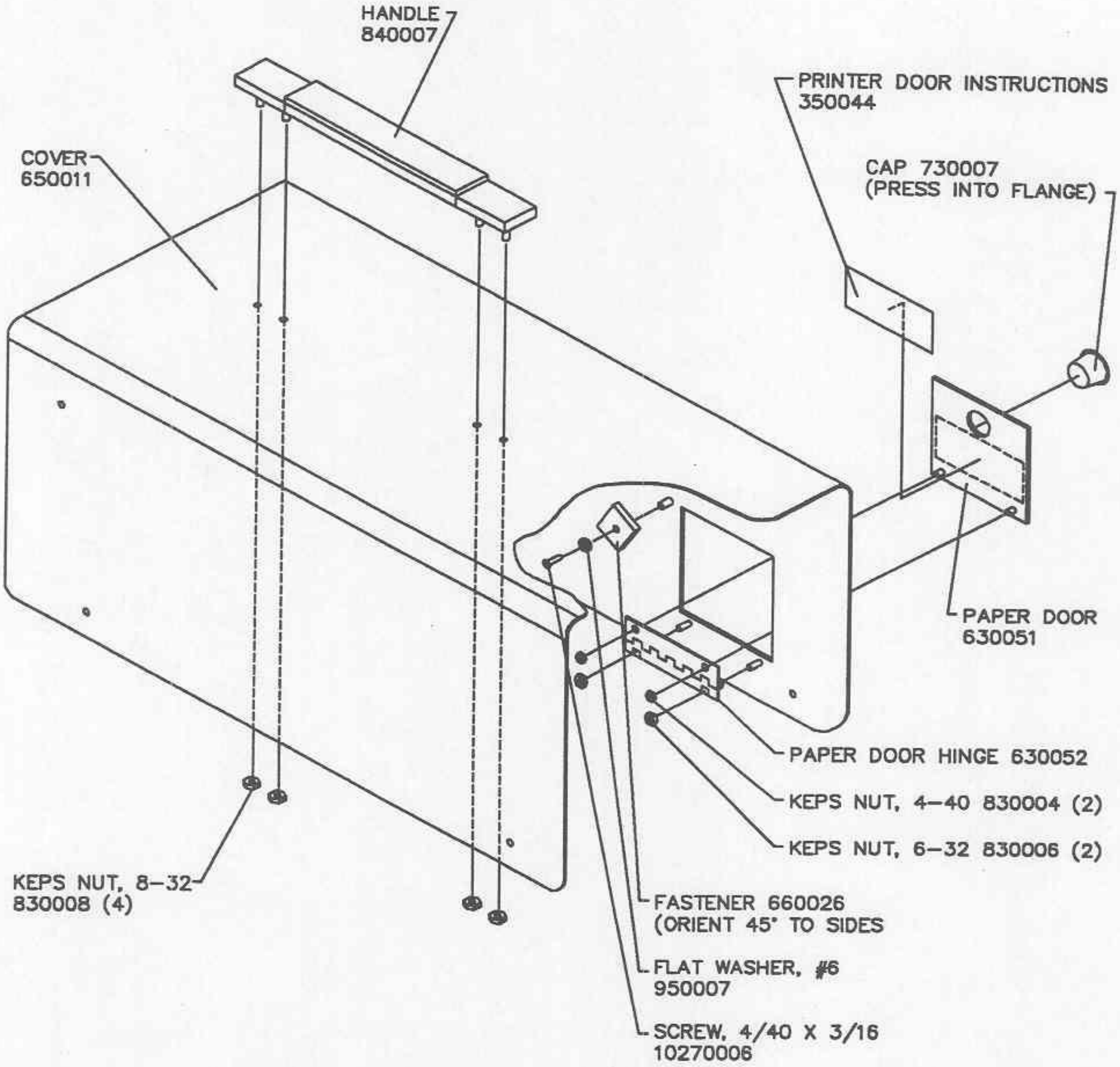

HANDLE
840007
PRINTER DOOR INSTRUCTIONS
350044
COVER
650011
CAP 730007
(PRESS INTO FLANGE)
PAPER DOOR
630051
PAPER DOOR HINGE 630052
KEPS NUT, 4–40 830004 (2)
KEPS NUT, 6–32 830006 (2)
KEPS NUT, 8–32
830008 (4)
FASTENER 660026
(ORIENT 45° TO SIDES
FLAT WASHER, #6
950007
SCREW, 4/40 X 3/16
10270006

Fig. 7-14, Cover Assembly.

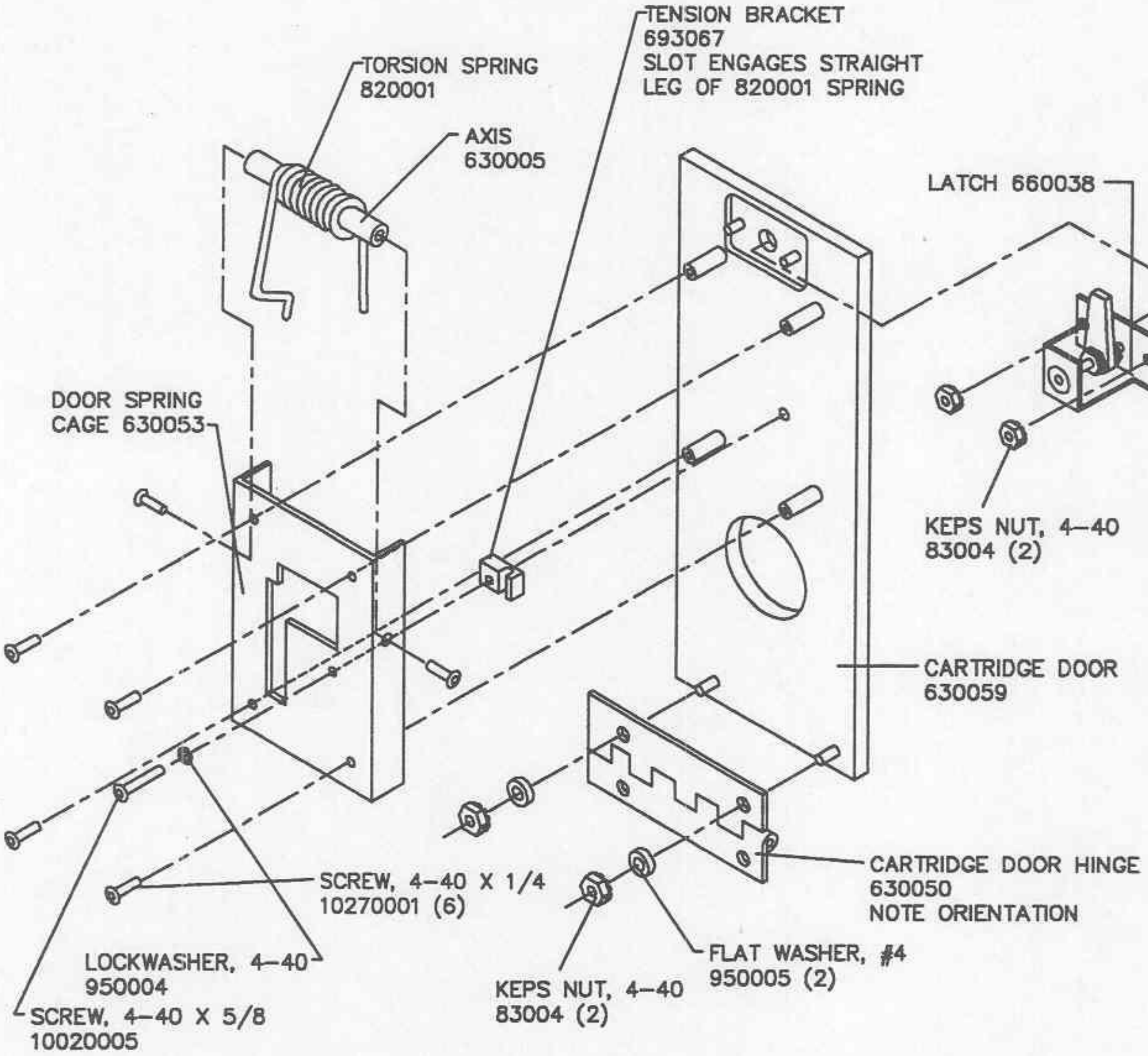

TENSION BRACKET
693067
SLOT ENGAGES STRAIGHT
LEG OF 820001 SPRING
TORSION SPRING
820001
AXIS
630005
LATCH 660038
DOOR SPRING
CAGE 630053
KEPS NUT, 4-40
83004 (2)
CARTRIDGE DOOR
630059
CARTRIDGE DOOR HINGE
630050
NOTE ORIENTATION
SCREW, 4-40 X 1/4
10270001 (6)
FLAT WASHER, #4
950005 (2)
LOCKWASHER, 4-40
950004
KEPS NUT, 4-40
83004 (2)
SCREW, 4-40 X 5/8
10020005

Fig. 7-15, Cartridge Door Assembly.

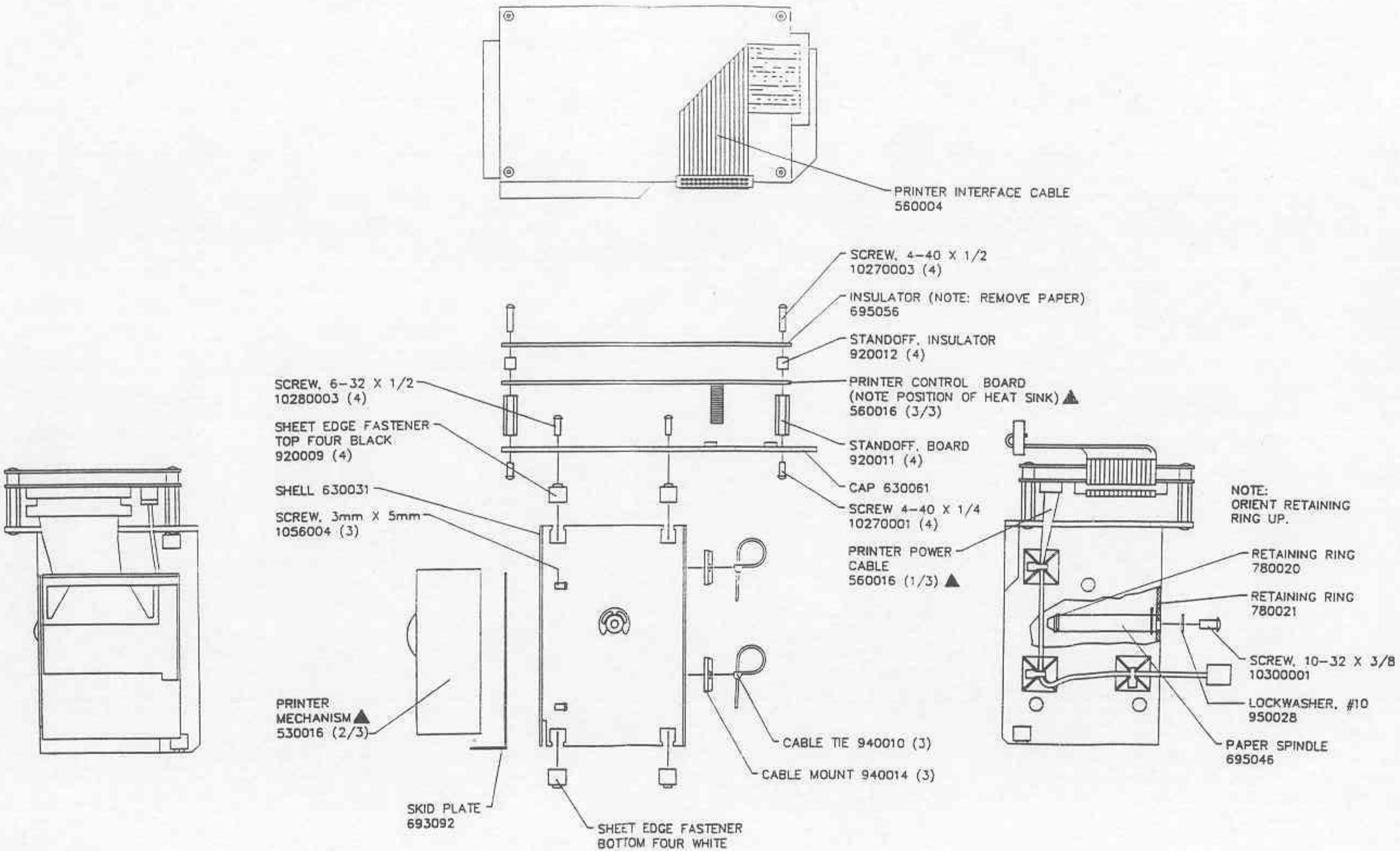

PRINTER INTERFACE CABLE 560004
SCREW, 4-40 X 1/2 10270003 (4)
INSULATOR (NOTE: REMOVE PAPER) 695056
STANDOFF, INSULATOR 920012 (4)
PRINTER CONTROL BOARD (NOTE POSITION OF HEAT SINK) ▲ 560016 (3/3)
STANDOFF, BOARD 920011 (4)
CAP 630061
SCREW 4-40 X 1/4 10270001 (4)
PRINTER POWER CABLE 560016 (1/3) ▲
SCREW, 6-32 X 1/2 10280003 (4)
SHEET EDGE FASTENER TOP FOUR BLACK 920009 (4)
SHELL 630031
SCREW, 3mm X 5mm 1056004 (3)
PRINTER MECHANISM ▲ 530016 (2/3)
SKID PLATE 693092
SHEET EDGE FASTENER BOTTOM FOUR WHITE 920015 (4)
CABLE TIE 940010 (3)
CABLE MOUNT 940014 (3)
NOTE: ORIENT RETAINING RING UP.
RETAINING RING 780020
RETAINING RING 780021
SCREW, 10-32 X 3/8 10300001
LOCKWASHER, #10 950028
PAPER SPINDLE 695046

Fig. 7-16, Printer Assembly.

7.5 COMPLETE GEM STAT PARTS LIST

MSS PART #	PART NAME, AND DESCRIPTION
10010001	Screw, 2-56x3/8, pan, head, black
10010003	Screw, 2-56x1/8, pan, slot, zinc
10010005	Screw, 2-56x1/2, pan, slot, black
10020005	Screw, 4-40x5/8, pan head, black
10120006	Screw, 4-40x1-1/4, flat, slot, zinc
10120007	Screw, 4-40x5/8, flat, phil, black
10130002	Screw, 6-32x5/8, flat, phil, black
10140001	Screw, 8-32x1/4, flat, phil, black
10140002	Screw, 8-32x1/2, flat, phil, black
10140004	Screw, 8-32x3/8, pan head, black
10270001	Screw, 4-40x1/4, button hd, black
10270003	Screw, 4-40x1/2, hd black
10270006	Screw, 4-40x3/16, button, hd, soc
10280001	Screw, 6-32x1/4, button, hd, soc
10280003	Screw, 6-32x1/2, button, hd, black
10290001	Screw, 8-32x3/8, button hd, black
10290002	Screw, 8-32x1/4, button, hd, black
10290003	Screw, 8-32x1/2, buttonn, hd, black
10290004	Screw, 8-32x5/8, button, hd, black
10290005	Screw, 8-32x3/4, button, hd,.black
10290007	Screw, 8-32x5/16, button, hd, soc, black
10300001	Screw, 10-32x3/8, button, hd, black
10330001	Screw, 6-56x1/2, flat, soc, black
10560004	Screw, 3mm x 5mm, flat, hd, slot
10560007	Screw, 8-32, soc, hd, shoulder, ss
10560014	Screw, 4-40, soc, hd, shoulder, ss
10650006	Screw, 1/4-20x1/2, soc, hd.
450008	Heater block/buffer Amplifier Assy.
450014	Subassy, front panel locking,
450015	Subassy, locking inner wall, GEM Stat
480006	A/D board assy, GEM Stat
500018	AC power board, GEM Stat & GEM6
500025	Solenoid driver PC board
550007	Main transformer, xfmr-1
550022	Subassy, Rear Panel, GEM Stat
550024	Subassy, Cart. Door, locking GEM Stat
560003	Subassy, Printer, GEM Stat & GEM6
560004	Printer Interface Cable, (30 pin)
560016	Printer Power Cable (4 pin)
560017	Pump Roller Assy
560019	Photo Sensor Cable
560022	Subassy, cover, GEM Stat
560023	Main Harness, ribbon cable

MSS PART #	PART NAME, AND DESCRIPTION
560027	Solenoid Driver Cable
560030	Ground Strap
590014	Paper Door Weldment, GEM Stat
610005	Membrane switch, GEM Stat
630005	Axis, door spring
630019	Bracket, mtg, line filter,
630031	Shell, printer
630040	Semi-hat
630042	Sight limiter, photo sensor
630050	Cartridge door hinge
630051	Door, paper GEM Stat
630052	Hinge, paper door
630053	Cage of door spring (new)
630054	Slide holder, interlock
630055	Door stop, interlock
630056	Slide interlock
630057	Gadget bracket, interlock
630058	Solenoid brkt (k2), interlock
630059	Cartridge door, GEM Stat
630060	Front panel, GEM Stat
630061	Cap, printer
640013	Rear Panel, GEM Stat universal
650004	Left-hand Guide Rail
650005	Right-hand Guide Rail
650006	Chassis, bottom plate
650011	Cover, GEM Stat
660026	Faster, magnet, fabricated
660037	Cartridge Enable Switch (SW1)
660038	Latch assy.
670002	Trimmed card guide
670002	Trimmed card guide
693036	Iron angle
693066	Tear off strip
693067	Tension bracket, spring
693076	Perforated "I" plate
693092	Skid plate, printer
695013	Standoff, nylon/delrin
695029	Inner wall, narrow
695030	Inner wall, long
695031	Holder of perpendicular
695032	Rail, lower left
695033	Rail, lower right
695034	Rail, high left
695035	Spacer, low, 1.56 long

MSS PART #	PART NAME, AND DESCRIPTION
695036	Spacer, high, 1.81 long
695037	Rail, high right
695038	Gutter
695040	Valve Control Arm
695046	Printer, paper spindle
695056	Insulator, printer
695058	A/D Board Insulator
695074	Insulator, bottom (Heater block)
700025	Fan, 3 1/8
700027	Fan guard, Filter retainer, filter media for fan
730001	Foot, rubber
730007	Cap, plastic, blk
750000	Valve motor
750005	Pump motor
760003	Teflon tape, 1" wide
760023	Tubing, heat shrink, 3/16 id, blk
770093	Terminal block (7 position)
770130	Connector, primary power
770131	Plug, grounding "euro"
770143	Jack/Socket Assy, Short
770148	Faston tab, .250 series
780020	Retaining ring, external 3/8, SS
780021	Retaining ring, external 3/8, ss
780024	Pop rivet. 1/8 dia., Al
790018	Transformer, Isolated, xfmr-2
810004	Photo micro sensor
820001	Spring, torsion, ss
820008	Spring, compression
830004	Keps nut, 4-40
830006	Keps nut, 6-32
830008	Keps nut, 8-32
830010	Keps nut, 10-32
830012	Hex nut, #2-56
830015	Hex nut, 4-4-, 3/16 across flats
830023	Nut, 0.8 d/mg "euro"
850000	A/D Board card guide, 4 1/2"
850001	A/D Board card guide, 6"
870006	Door Lock Solenoid (k1), 24v, 10%, ms-6
870007	Cartridge Enable Solenoid (k2), inner wall, 24v, 25%
880001	Diode, IN4003
91001007	Capacitor, Mp, 250vdc, 0.1mfd
920009	Sheet edge fastener
920011	Stand-off, printer PC board
920012	Stand-off, insulator
920012	Stand-off, insulator

MSS PART #	PART NAME, AND DESCRIPTION
920015	Sheet edge fastener, 8-32, white
920017	Stand-off, .115 id x 3/16" long
930029	Power switch/circuit breaker 1.5a
930032	Home switch (SW2)
930034	Door Lock Switch (SW3), 0.1amp.,125v,
940010	Cable tie, 3.9" long, mini
940014	Mount, cable tie
940041	Ribbon cable clamp
950001	Flat washer, nylon #8
950002	Flat washer, #2, ss
950004	Lock washer, 4-40
950005	Flat washer, #4
950011	Flat washer, #10
950018	Flat washer, nylon, #4
950023	Lock washer, internal, #2, ss
950026	Flat washer, m6 "euro"
950027	Washer, external-tooth lock m6
950028	Lock washer, #10 internal tooth
960001	Line Filter, UL approved
960013	Varister, 130 VAC, 38 joules
960017	Color marking disk, "euro"

CHAPTER 8; ELECTRICAL CIRCUITS

8.1 POWER SUPPLY

The GEM Stat Power Supply consists of the Power Supply Assembly (Part #500018); Main transformer (#550007) and Isolation transformer (#790018); and some parts on the A/D Board assembly (#500027).

Isolated Power Supply

The Isolated Power Supply provides power to the analog circuitry of the Heater Block Amplifier and A/D Board. All circuitry that is powered by this isolated supply is optically isolated from the CPU and other components powered by the Main Power Supply. The isolated power is supplied by the Isolation Transformer and Isolation regulator circuitry located on the A/D Board.

P7 receives approximately 21 VAC from the secondary of the isolated power transformer located on the rear panel. Positive half-wave rectification and filtering is performed by D11 and C34, and negative rectification and filtering is performed by D12 and C36. VR1 is a standard 7815 type regulator and supplies regulated (+) 15VDC. VR2 supplies regulated(-) 15VDC. VR3 is a precision shunt regulator which supplies 2.500 VDC reference voltage. RV2 is used to trim this voltage. 21VAC from P7 is also applied to K1, a solid State relay. K1 cycles power on and off, under microprocessor control, to the heater in the heater block.

Main Power Supply

The main supply provides regulated DC and AC voltages to the digital part of the A/D Board Assembly, the printer, motors and solenoids. The main supply is divided into the following functional groups:

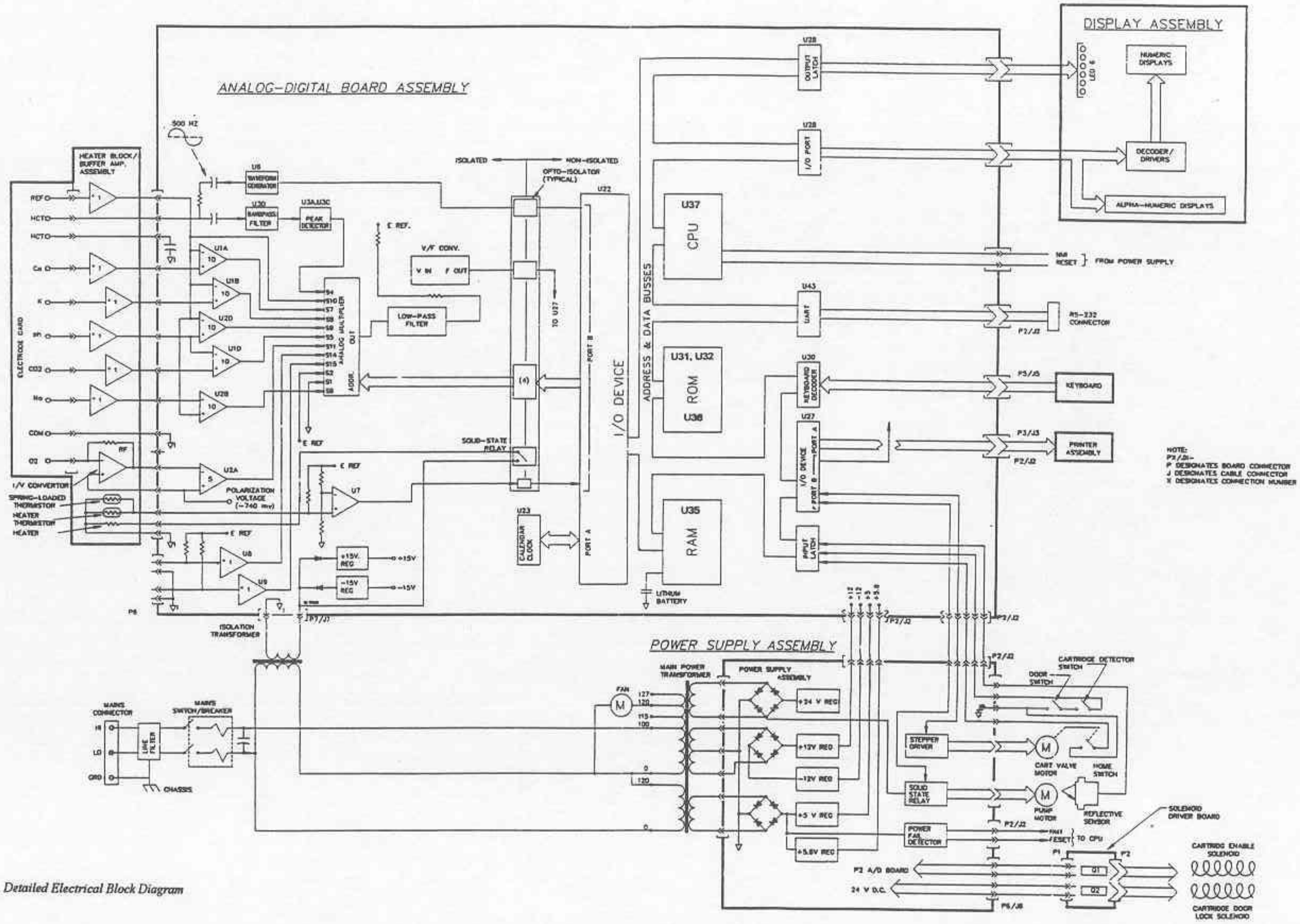
- D.C. Power Supply
- Power Fail Detect Circuit
- Motor Control
- Signal Interconnection

DC Power Supply

The D.C. Power Supply is the 500018 Power Supply Assembly and the Main Transformer (#550007) are both mounted on the chassis of the GEM STAT Instrument just forward of the rear panel.

The Main Power Supply provides the following voltages:

- 24 VDC @ 750 mA
- 12 VDC @ 400 mA
- -12 VDC @ 100 mA
- 5 VDC @ 3 A
- 5.6 VDC @ 50 mA


ANALOG–DIGITAL BOARD ASSEMBLY
DISPLAY ASSEMBLY
POWER SUPPLY ASSEMBLY
HEATER BLOCK/ BUFFER AMP. ASSEMBLY
ELECTRODE CARD
REF
HCT
HCT
Ca
K
pH
CO2
Na
COM
O2
I/V CONVERTOR
SPRING–LOADED THERMISTOR
HEATER THERMISTOR
HEATER
RF
500 HZ
U6 WAVEFORM GENERATOR
U30 BANDPASS FILTER
U3A,U3C PEAK DETECTOR
U1A
U1B
U2D
U1D
U2B
U2A
POLARIZATION VOLTAGE (~740 mv)
U7
U8
U9
E REF
+15V. REG
−15V REG
+15V
−15V
ANALOG MULTIPLEXER
S4
S10
S7
S8
S9
S5
S11
S14
S15
S2
S1
S8
OUT
ADDR.
LOW–PASS FILTER
V/F CONV.
V IN
F OUT
ISOLATED
NON–ISOLATED
OPTO–ISOLATOR (TYPICAL)
TO U27
(4)
SOLID–STATE RELAY
U23 CALENDAR CLOCK
U22 I/O DEVICE
PORT A
PORT B
ADDRESS & DATA BUSSES
U37 CPU
U31, U32 ROM U38
U35 RAM
LITHIUM BATTERY
U28 OUTPUT LATCH
U28 I/O PORT
U43 UART
U30 KEYBOARD DECODER
U27 I/O DEVICE
PORT A
PORT B
INPUT LATCH
LED 6
NUMERIC DISPLAYS
DECODER/ DRIVERS
ALPHA–NUMERIC DISPLAYS
NMI
RESET
FROM POWER SUPPLY
RS–232 CONNECTOR
P2/J2
P5/J5
KEYBOARD
P3/J3
P2/J2
PRINTER ASSEMBLY
P8
P7/J7
ISOLATION TRANSFORMER
+12
−12
+5
+5.8
P2/J2
MAINS CONNECTOR
HI
LO
GRD
LINE FILTER
CHASSIS
MAINS SWITCH/BREAKER
FAN
M
127
120
115
100
0
120
0
MAIN POWER TRANSFORMER
POWER SUPPLY ASSEMBLY
+24 V REG
+12V REG
−12V REG
+5 V REG
+5.8V REG
STEPPER DRIVER
SOLID STATE RELAY
POWER FAIL DETECTOR
P2 A/D BOARD
24 V D.C.
P6/J6
CARTRIDGE DETECTOR SWITCH
DOOR SWITCH
CART VALVE MOTOR
HOME SWITCH
PUMP MOTOR
REFLECTIVE SENSOR
P2/J2
FAIL
RESET
TO CPU
SOLENOID DRIVER BOARD
P1
P2
Q1
Q2
CARTRIDG ENABLE SOLENOID
CARTRIDGE DOOR LOCK SOLENOID

NOTE:
PX/JX–
P DESIGNATES BOARD CONNECTOR
J DESIGNATES CABLE CONNECTOR
X DESIGNATES CONNECTION NUMBER

Figure 8-1, Detailed Electrical Block Diagram

- *+24 VDC Operation*

32 VAC is supplied from the orange secondary winding of the transformer assembly 550007 to P1-4 and P1-6 of the 500018 assembly. The 32 VAC passes through 3 amp PTC Device F1 and across capacitor C21 to diode bridge DB1. C21 suppresses noise generated by the diodes of DB1. Diode bridge DB1 full wave rectifies the voltage to approximately 32 VDC. This 32 VDC is filtered by capacitors C1 and C10 and is input to voltage regulator U1. The resistors- R2, R3 and RV1 form a voltage divider to set the output of U1. RV1 is adjusted to get 24 VDC at test point TP1. LED 1 is an indicator that U1 is functioning. R1 limits the current to LED 1. The diode D1 passes reverse emf from major load changes around U1, preventing damage to U1. Capacitor C3 improves transient response of the supply and R4 provides a minimum load to keep U1 turned on. The 24 VDC is presented to the rest of the GEM Stat System at P4-4 and P2-36 & 38.

- *+12 and -12 VDC Operation*

40 VAC is supplied from the blue center tapped secondary winding of the transformer assembly 550007 to P1-7, 8 & 9 of the 500018 assembly. The 40 VAC passes through 1.6 amp PTC Devices F2 and F3 to diode bridge DB2. C22 suppresses noise generated by the switching of diode bridge DB2. Diode bridge DB2 full wave rectifies the input voltage to approximately 20 VDC at C4 and -20 VDC at C7. Capacitors C4 and C5 filter the voltage to the input of voltage regulator U2. Resistors R6 and R7 form a voltage divider to set the output of U2 to (+) 12 (+/- 0.6) VDC. LED 2 indicates operation of U2. Resistor R5 limits current to LED2. Diode D2 passes reverse emf around U2. Capacitor C6 improves transient response of the supply. Resistor R8 provides a minimum load to U2. The regulated 12 VDC is presented to the rest of the GEM Stat system at P2-25&26. The (-) 20 VDC is filtered by capacitors C7 and C8 at the input of voltage regulator U3. The output of U3, (-) 12 (+/-0.6) VDC is present at test point TP3. LED 3 indicates the operation of U3. Resistor R9 limits the current to LED3. The regulated -12 VDC is presented to the rest of the GEM Stat System at P2-34.

- *+5 VDC Operation*

10 VAC is supplied from the brown secondary winding of the transformer assembly 550007 to P1-3 and P1-5. The 10 VAC passes through fuse F4 and across capacitor C23 to diode bridge DB3. C23 suppresses noise generated by DB3. Diode bridge DB3 full wave rectifies the voltage to 10 VDC. The 10 VDC is filtered by capacitors C2 and C11 and is input to voltage to regulator U4. The resistors R10, R11 and RV2 form a voltage divider to set the output of U4. RV2 is adjusted to get 5 VDC at Test Point TP4. Diode D3 protects U4 from back emf. LED 4 indicates operation of U4. Resistor R20 limits current to LED4. Capacitor C12 improves transient response of the supply. Resistor R12 provides a minimum load to U4. Zener diode Z1 limits the output voltage to 5.1 VDC in the event of an over voltage failure of U4, protecting the microprocessor circuitry on the A/D Board Assembly. The regulated 5 VDC is presented to the rest of the GEM Stat System at P2-37, 39, 48, 50 and P4-1.

- *+5.6 VDC Operation*

  The 5.6 VDC Supply gets 10 VDC from the output of diode bridge DB3. The 10 VDC is filtered by capacitor C13 and input to voltage regulator U5. Resistors R13, R14 and diode D5 form a voltage divider from the 5 VDC supply to set the output of U5 at one diode drop (0.6 VDC) above the 5 VDC supply. Capacitor C14 filters noise from D5 to ground. The output of U5, 5.6 VDC regulated is present at test point TP5. Capacitor C15 improves the transient response of the supply. Resistor R15 provides a minimum load for U5. LED 5 indicates operation of U5. Resistor R21 limits the current to LED5. The regulated 5.6 VDC is presented to the rest of the GEM Stat System at P2-49.

Power fail detect circuit

The power fail detect circuit has two inputs from the DC supply section of the Power Supply Assembly. These monitor the unregulated input to the 5 VDC regulator and the output of the 5 VDC regulator. The circuit provides two outputs to the microprocessor, Shut Down and Power Fail. The Power Fail Detect circuit is powered by the +12 VDC supply during normal operations. Diode D9 and Capacitor C18 combine to isolate the power to the Power Fail circuit from the +12 VDC if +12 VDC falls to 11.4v during a power fail.

Operation During Power Up

1. Before power is applied to the circuit, capacitor C17 is discharged.
2. Power On:
   - +12 Volts powers up on amp U6
   - Voltage ref SCR1 comes on at 5V
   - U6-1 goes high & SHUT DOWN goes high (reset to microprocessor)
   - U6-7 goes low
3. 5 VDC raw voltage reaches approximately 5.5 V.
   - C17 begins charging through resistor R18-is still less than 5V. Therefore U6-1 stays high, P2-41 is high keeping the microprocessor reset.
4. All supplies are up to regulated voltages.
   - C17 is still charging up
   - SHUT DOWN is still high
5. C17 reaches +5 V (on its way to 5.6 V)
   - U6-1 goes low - SHUT DOWN goes low -microprocessor is released from reset.

Operation During a Power Fail

There are two types of power failure detected by the Power Fail Detect circuit. They are voltage drop from the secondary of the Main Transformer and regulated 5 VDC dropped below 5V. In the first instance, power fail is given BEFORE shut down and in the second, shut down occurs INDEPENDENTLY of power fail.

Case I- Power Fail - transformer voltage drops:

1. Power On.
   - C17 is charged to 5.6 V.
   - R16 voltage is approximately 10 V.
2. Transformer voltage drops
   - R16 voltage drops to 7 V
   - U6-7 goes low - POWER FAIL goes low (NMI to microprocessor)
   - C17 begins to discharge through R18
3. Approximately 10 milliseconds later:
   - C17 reaches 5 (-) Volts on its way to 0 V.
   - U6-1 goes high - SHUT DOWN goes high (reset to microprocessor)
   - Recovery from power fail due to transformer voltage drop follows exactly the Power Up sequence.

Case 2.-- Power Fail - 5 VDC Drops:

1. Power On
   - C17 is charged to 5.6 V
2. 5 VDC drops
   - C17 begins to discharge through D10 and R25
3. Approximately 160 micro seconds later:
   - C17 reaches 5 (-) Volts
   - U6-1 goes high - SHUT DOWN goes high (reset to microprocessor)

Recovery from power fail due to 5V drop:

1. 5VDC goes up to 5 Volts
   - C17 begins to charge through R18
2. C17 reaches 5 (+) Volts
   - U6-1 goes low - SHUT DOWN goes low (RESET removed from microprocessor.

Power Fail Circuit Description:

Resistors R16 and R17 form a voltage divider to set the transformer power fail threshold (7VDC). Resistors R27 and R28 and diode D11 are a voltage divider to give hysteresis on transformer power fail, i.e. U6-7 goes low at V (R17) = 5V and goes high at V (R17) = 5.5V. Resistors R29 and R30 form a voltage divider to shift the output level of U6-7 to a TTL level. Resistor R18 and capacitor C17 are an R-C delay network to delay U6-1 activity from U6-7. Diode D10 keeps C17 from charging from the output of voltage regulator U4. Resistor R25 slows the discharge of C17 in the event of a 5VDC drop power fail to insure noise immunity. Voltage reference SCR1 generates a stable reference voltage of 5.00 VDC. Resistor R19 limits current through SCR1. Diode D9 isolates the voltage on capacitor C18 from the +12 V supply in the event of power failure.

Motor Control Circuitry on the Power Supply Board

The Power Supply Assembly directly controls the Valve Motor (M1) and the Pump Motor (M2).

The Valve Motor is controlled by the stepper motor driver U7 which is in turn controlled by the signals CVRT (Cartridge Valve Rate), P2-43; CVEN (Cartridge Valve Enable), P2-44; and DIR (Direction), P2-10. R22 is a current limit for U7 and Q7 gates current to the Valve Motor.

The Pump Motor is controlled by the solid State relay U8. R28 limits current to the coil portion of U8. Capacitors C20 and C24 are phase shifting capacitors to the pump motor.

Signal Interconnection

The following signals from Inner Wall Assembly are passed across the Power Supply board

Connector/Pin In	Connector/Pin Out
P3/20	P2/31
P3/16	P2/30
P3/18	P2/32
P3/5	To Photo detect LED on M2

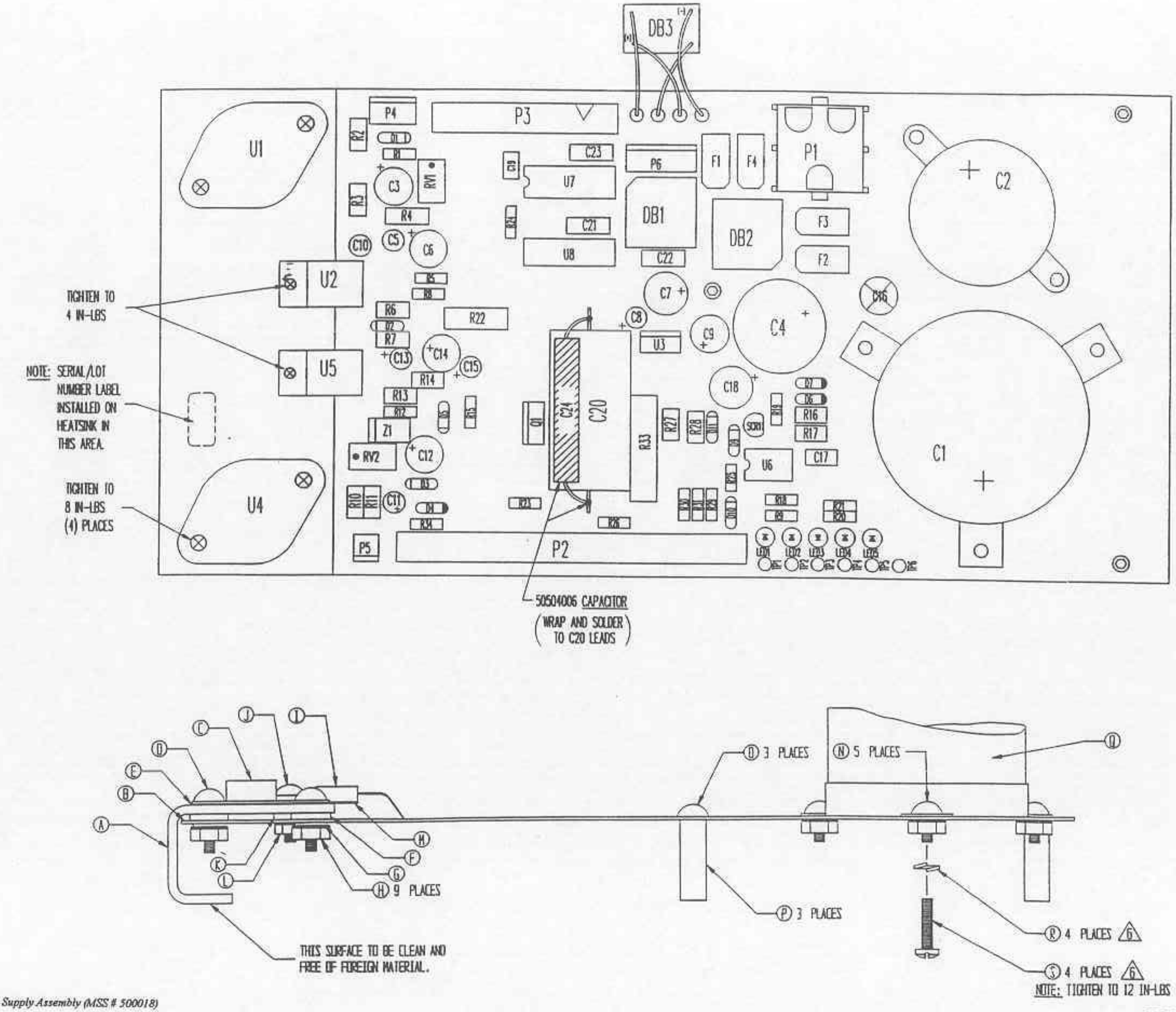
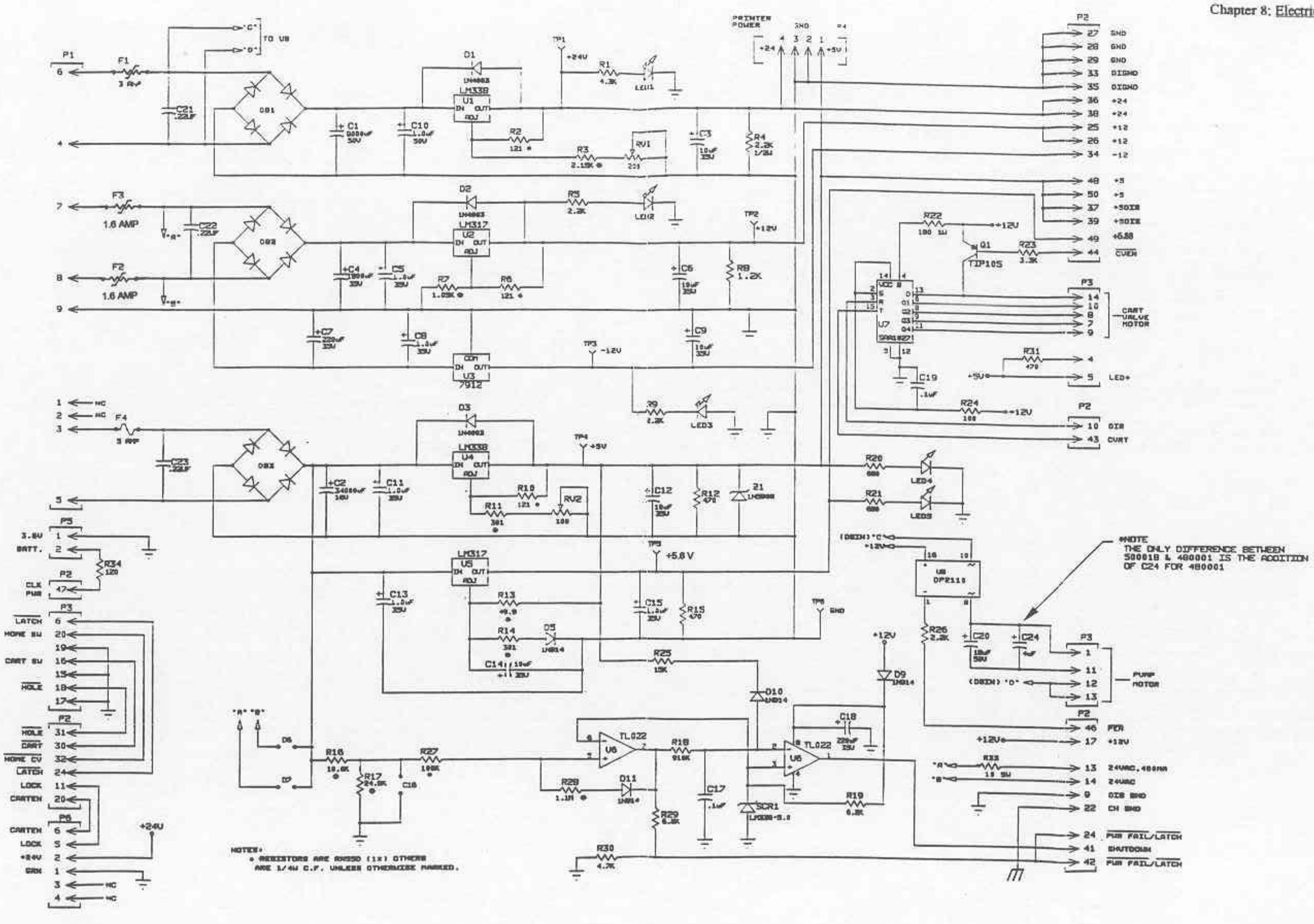

DB3
U1
U4
U2
U5
P1
P2
P3
P4
P5
P6
DB1
DB2
C1
C2
C4
C20
C24
F1
F2
F3
F4
TIGHTEN TO
4 IN-LBS
NOTE: SERIAL/LOT
NUMBER LABEL
INSTALLED ON
HEATSINK IN
THIS AREA.
TIGHTEN TO
8 IN-LBS
(4) PLACES
50504006 CAPACITOR
(WRAP AND SOLDER
TO C20 LEADS)
Ⓐ
Ⓑ
Ⓔ
Ⓓ
Ⓒ
Ⓙ
Ⓘ
Ⓜ
Ⓕ
Ⓖ
Ⓚ
Ⓛ
Ⓗ 9 PLACES
Ⓓ 3 PLACES
Ⓝ 5 PLACES
Ⓞ
Ⓟ 3 PLACES
Ⓡ 4 PLACES 6
Ⓢ 4 PLACES 6
NOTE: TIGHTEN TO 12 IN-LBS
THIS SURFACE TO BE CLEAN AND
FREE OF FOREIGN MATERIAL.

Fig. 8-2, Power Supply Assembly (MSS # 500018)


P1
F1
3 AMP
C21
.22uF
TO U8
"C"
"D"
DB1
D1
1N4003
LM338
U1
IN OUT
ADJ
C1
C10
R2
121
R3
2.15K
RV1
TP1
+24V
R1
4.3K
LED1
C3
R4
2.2K
1/2W
PRINTER POWER
+24
GND
+5V
P4
P2
27 GND
28 GND
29 GND
33 DIGND
35 DIGND
36 +24
38 +24
25 +12
26 +12
34 -12
48 +5
50 +5
37 +5DIS
39 +5DIS
49 +6.88
44 CVEN
F3
1.6 AMP
C22
.22uF
DB2
D2
LM317
U2
C4
C5
R7
1.05K
R6
121
R5
2.2K
LED2
TP2
+12V
C6
R8
1.2K
F2
1.6 AMP
C7
C8
COM
U3
7912
TP3
-12V
C9
R22
100 1W
Q1
TIP105
R23
3.3K
VCC 8
U7
SAA1027
C19
.1uF
P3
14
10
8
7
9
CART VALVE MOTOR
R31
470
+5V
4
5 LED+
R24
100
+12V
P2
10 DIR
43 CVRT
R9
2.2K
LED3
NC
F4
3 AMP
C23
.22uF
DB3
D3
1N4003
LM338
U4
C2
34000uF
16V
C11
R10
121
R11
301
RV2
100
TP4
+5V
C12
R12
470
Z1
R20
680
LED4
R21
680
LED5
P5
3.8V BATT.
R34
120
CLK PWR
47
LATCH 6
HOME SW 20
19
CART SW 16
15
HOLE 18
17
HOLE 31
CART 30
HOME CV 32
LATCH 24
LOCK 11
CARTEN 20
P6
CARTEN 6
LOCK 5
+24V 2
GRN 1
3 NC
4 NC
+24V
LM317
U5
C13
R13
49.9
R14
301
D5
1N914
C14
TP5
+5.8 V
C15
R15
470
TP6
GND
(DBDIN) "C"
+12V
U8
DF2110
R26
2.2K
C20
10uF
50V
C24
P3
1
11
12
13
PUMP MOTOR
(DBDIN) "D"
"A" "B"
D6
D7
R16
10.0K
R17
24.0K
C16
R27
100K
TL022
U6
R18
910K
R28
1.1M
D11
1N914
R29
6.8K
C17
.1uF
R25
15K
D10
1N914
SCR1
C18
220uF
35V
R19
6.8K
D9
1N914
+12V
R30
4.7K
P2
46 PFR
17 +12V
R33
10 5W
13 24VAC, 400MA
14 24VAC
9 DIS GND
22 CH GND
24 PWR FAIL/LATCH
41 SHUTDOWN
42 PWR FAIL/LATCH

*NOTE
THE ONLY DIFFERENCE BETWEEN 500018 & 480001 IS THE ADDITION OF C24 FOR 480001

NOTES:
* RESISTORS ARE RN55D (1%) OTHERS ARE 1/4W C.F. UNLESS OTHERWISE MARKED.

Fig 8-3. Power Supply Assembly (MSS # 500018) Schematic

Parts List for Power Supply Board (refer to schematic figure 8-3)

QTY	MSS PART #	LOCATION	DESCRIPTION
4	10030005	D	SCREW, 6-32x1/2
2	10270002	J	SCREW, 4-40x3/8
5	10280002	N	SCREW, 6-32x3/8
3	10290001	O	SCREW, 8-32x3/8
4	10560015	S	SCREW, 10-32x1/2
1	31052010	R33	RESISTOR, WW, 5W,5%,10 OHM.
1	34101499	R13	RESISTOR, MF,1/8W,1%,49.9 OHM.
3	34102121	R2,R6,R10	RESISTOR,MF,1/8W,1%,121 OHM.
2	34102301	R11,R14	RESISTOR,MF,1/8W,1%,301 OHM.
1	34103105	R7	RESISTOR,MF,1/8W,1%,1050 OHM
1	34103215	R3	RESISTOR,MF,1/8W,1%,2150 OHM
1	34104100	R16	RESISTOR,MF,1/8W,1%,10 K.
1	34104249	R17	RESISTOR,MF,1/8W,1%,24.9K
1	34105100	R27	RESISTOR,MF,1/8W,1%,100K
1	34106110	R28	RESISTOR,MF,1/8W,1%,1.1 MEG.
1	34452100	R24	RESISTOR.,CC,1/4W,5%, 100 OHM.
1	34452120	R34	RESISTOR, CF,1/4W,5%, 120 OHM.
3	34452470	R12,R15, R31	RESISTOR, CF,1/4W,5%, 470 OHM.
2	34452680	R20,R21	RESISTOR.,CC,1/4W,5%, 680 OHM.
1	34453120	R8	RESISTOR, CF,1/4W,5%, 1.2K OHM.
3	34453220	R9,R5,R26	RESISTOR,MF,1/4W,5%,2.2K.
1	34453330	R23	RESISTOR,MF,1/4W,5%,3.3K.
1	34453430	R1	RESISTOR,MF,1/4W,5%,4.3K.
1	34453470	R30	RESISTOR,MF,1/4W,5%,4.7K.
1	34453620	R19	RESISTOR,MF,1/4W,5%,6.2K
1	34453680	R29	RESISTOR,MF,1/4W,5%,6.8K.
1	34454150	R25	RESISTOR,CC,1/4W,5%,15K.
1	34455910	R18	RESISTOR,MF,1/4W,5%,910K.
1	34512180	R22	RESISTOR,MF,1/4W,5%,180 OHM.
1	34553220	R4	RESISTOR,MF,1/2W,5%,2.2K.
1	48202100	RV2	POT.,20 TURN, 100 OHMS
1	48202200	RV1	POT.,20 TURN, 200 OHMS.
1	50501805	C20	CAP.,POLY,METAL,50V,18 MF.
1	600025	N/A	PRINTED CIRCUT BOARD
1	630033	A	HEATSINK
2	65521007	C17,C19	CAP.,CERAMIC,50V, 0.1 MF.
3	65542208	C21,C22, C23	CAP.,MONO CERAMIC, 100V,0.22 MF.
5	70351005	C3,C6,C9, C12,C14	CAP.,TANTALUM,35V,10 MF.
5	70351006	C5,C8,C11, C13, C15	CAP., TANTALUM,35V, 1.0 MF.
1	70501006	C10	CAP., TANTALUM,50V, 1.0 MF.

QTY	MSS PART #	LOCATION	DESCRIPTION
2	730004	M	INSULATOR, TO-220.
2	730005	E	INSULATOR, TO-3
5	740005	LED1-LED5	LED, HI EFFICIENCY.
1	770013	U7	SOCKET, 16 PIN DIP.
1	770047	P4	CONNECTOR, 4 PIN HEADER.
1	770064	P2	CONNECTOR,50 PIN HEADER
1	770070	P1	CONNECTOR,20 PIN, HEADER
1	770073	P3	CONNECTOR,9 PIN,HEADER
1	770112	P5	CONNECTOR,2 PIN HEADER
1	770135	P6	CONNECTOR,6 PIN HEADER
8	770142	F1-F4	SOCKET,1-PIN,KNURL MOUNT
1	780011	C2	CLAMP,CAPACITOR
1	780012	C1	CLAMP CAPACITOR
1	80000001	C2	CAP.,ELECT.,16V,34000 MF
1	80000002	C1	CAP.,ELECT., 50V,9000 MF
2	80352204	C7,C18	CAP.,ELECT.,35V,220 MF.
1	80401804	C4	CAP.,ELECT.,35V,1800 MF.
2	830004	L	KEPS NUT,#4-40
9	830006	H	KEPS NUT, #6-32
1	860023	F4	FUSE,FERRILE,GLASS,250V,5 AMP.
2	860024	F2,F3	PTC RESISTANCE DEVICE,1.6 AMP.
1	860025	F1	PTC RESISTANCE DEVICE,3.0 AMP.
1	870004	U8	RELAY,SOLID-STATE,1 AMP.
3	880001	D1-D3	DIODE, IN4003
4	880005	D5,D9-D11	DIODE, IN914
1	880008	DB3	BRIDGE,RECTIFIER, 200V, 25 AMP.
1	880015	Z1	DIODE, ZENER, 5V
2	880016	DB1,DB2	BRIDGE,RECTIFIER, 200V, 6 AMP.
1	884005	Q1	TRANSISTER, DARLINGTON, PNP
2	888001	U1,U4	REGULATOR, VOLTAGE, 5V, 4 AMP.
2	888002	U2,U5	REGULATOR, VOLTAGE, 24V
1	888006	U7	DRIVER, IC, STEPPER
1	888025	U3	REGULATOR, FIXED, 1.5 AMP., -12V
1	888026	U6	OP.-AMP., DUAL LOW POWER
1	888027	SCR1	IC, VOLTAGE REF., 5.0V
3	920010	P	STAND-OFF, 8-32X3/4 ALUM.
-	940004	DB3(AC)	WIRE, 24 AWG., GRAY
-	940005	DB3(-)	WIRE, 24 AWG., GREEN
-	940007	DB3(+)	WIRE, 24 AWG., RED
3	940010	DB3	CABLE TIE, 3.9" LONG, MINITURE
4	950007	G	FLATWASHER #6
4	950016	F	SHOULDER WASHER, NYLON #6
2	950017	K	SHOULDER WASHER, NYLON #4
4	950025	R	LOCKWASHER, #10, MEDIUM, BRONZE

8.2 HEATER BLOCK AND TEMPERATURE CONTROL

The heater block is thermostatically maintained at a constant 37.0°C by a closed loop thermal control system. There are two thermistors in the heater block connected in parallel. One is in contact with the heating element, and the other is spring-loaded to make thermal contact with the metal plate on the side of the electrode card when a cartridge is installed.

The thermistor control circuitry is all contained on the A/D Board (refer to A/D schematic 1 of 3). The thermistors form one branch of a resistance bridge consisting of R50, R52, and R51 in parallel with R119 on the A/D Board. The voltage at the junction of R50 and R51/R119 is set to equal the voltage that should be developed across the thermistors at exactly 37°C. U7 is a comparator connected across the sides of the resistance bridge. The output of U7 will be low if the thermistor voltage is too low, indicating heater block temperature too high, and vice versa. The output of U7 is applied to Q1, which drives opto-isolator U19, the output of which connects to an input of the processor. If Heater block temperature is too low, the thermistor voltage will be higher than the reference voltage, the output of U7 will be high, Q1 will be turned on, and the output of isolator U19 will be low. The purpose of zener diode Z1 is to clamp the summing junction voltage at or low. The summing junction voltage, thus tracks block temperature. This voltage is applied to the MUX.

The heater in the block is driven by the secondary of the isolated power transformer switched by solid state relay K1 (A/D Board), which is controlled by the processor. Under normal conditions, if the output of isolator U19 is low, indicating that the block temperature is too low, the processor will turn on the solid state relay and apply voltage to the heater, and vice-versa. The average temperature of the heater block will then be under loop control and track the reference voltage established by the resistance bridge. The processor may under some circumstances, under program control, ignore the comparator output and either turn the heater off or on.

Connection to the electrode card in the cartridge is made by P1 which is a single row leaf-spring connector that makes sliding contact with the electrically conductive "fingers" on the electrode card. It must stay free of contaminants.

8.3 ANALOG-DIGITAL (A/D) CIRCUIT BOARD

Recent Changes to A/D board

Recent minor changes to IC U23 have resulted in several components being removed from the A/D board. The A/D board PCB layout (figure 8-4), lists these as, "Recent Changes - Parts Removed". A/D board Schematic (2 of 3) indicates these as missing components with the symbol (#). Although these components are not used, some A/D boards may still have them installed--In the future, these components will not be installed. The parts list does not include these components.

Unused Circuitry on the A/D Board

In the early stages of system development, the need to sense atmospheric pressure was anticipated but never required. The foil pattern is still on the P.C. board and the circuitry appears on A/D Schematic (1 of 3) enclosed in dotted lines. Components are not installed.

IC's U8 and U9 and related circuitry for external thermistor (P6) is not used in the GEM Stat. Components are encloseded in dotted lines on A/D Schematic (1 of 3) and included in the parts list.

Electrode Differential Amplifiers

All electrodes in the cartridge, except the Hematocrit Electrodes, are high impedance and are connected to unity-gain buffer amplifiers in the Buffer Amplifier/Heater Block Assembly. The outputs of these buffer amplifiers are then applied to differential amplifiers on the A-D Board.

- *pH, K+, Ca++ and Na+ Electrode Differential Amplifiers.*
  The pH, K+, Ca++ and Na+ electrodes generate a voltage proportional to the reference electrode. The reference electrode sets at approximately 350 millivolts (mV) above common and may vary. Hence, the reference electrode voltage must be subtracted from the voltage produced by the pH, K+, Ca++ and Na+ electrodes. U2D, U1B, U1A and U1C are differential amplifiers which subtract and amplify the difference potential by a factor of 10. The bottom leg resistor of the (+) input of each of these amplifiers is returned to the output of U4C instead of common. The output of U4C sets at about +358 millivolts (mV). This offsets the outputs of the differential amplifiers by 3.58 volts. These outputs would otherwise produce a negative voltage too large for the V/F Converter to accept. The output of these amplifiers is expressed at 10 (Ee-Er) (+) .358 mV, where Ee is the Active Electrode Voltage and Er is the Reference Electrode Voltage.

- *CO2 (Carbon Dioxide)Electrode Differential Amplifier.*
  The CO_2 Electrode develops a voltage proportional to CO_2 concentration with respect to the pH Electrode, therefore the CO_2 Differential Amplifier, U1D, accepts CO_2 and pH as inputs. It is configured for a gain of 10.

- *Reference Electrode Amplifier*
  U2C is a single-ended amplifier with a gain of 10 which amplifies the output of the Reference Electrode Buffer Amplifier. The Reference Electrode voltage is not used in any calculation, but is monitored by the processor.

- *O2 (Oxygen) Differential Amplifier and Polarization Circuit.*
  The Oxygen Electrode, unlike the other electrodes, develops a current instead of a voltage. A polarization voltage of about (-) 740mV is applied to the electrode. This voltage is developed by U2B, a unity gain inverter. From the output of this stage, the polarization voltage is routed through P1-17 to the non-inverting input of the O_2 buffer amplifier in the headstage. The output of this stage is a voltage proportional to oxygen riding on top of the

polarization voltage. To subtract the polarization voltage from this signal, it is applied to the inverting input of differential amplifier U2A, and the polarization voltage is applied to the non-inverting input. The output of this stage is proportional to O_2 concentration.

- *Hematocrit Circuit*
  Hematocrit (Hct), a measure of the concentration of red blood cells in the blood, is determined by an AC. conductance measurement. Conductance of the blood decreases as red blood cell (RBC) count increases. Two metal posts in the electrode chamber form a conductance cell. An AC. current is forced through the cell, and the resulting voltage is sensed. This voltage will be a function of RBC concentration, commonly referred to as Hematocrit (Hct).

  U6 is a function generator which develops a sine wave of about 500Hz at pin 2
  R46 and C22 set the frequency. This voltage is applied to R45, which establishes a current through the conductance cell. The AC. current is returned through C102 to ground. The resulting voltage is coupled through C16 to U3D, which is configured as a bandpass amplifier with a gain of 50 and a center frequency of 500 Hz. The amplified sine wave is applied to a positive peak detector, U3C and U3A. The output of this circuit is then a DC. voltage proportional to hematocrit.

  Q2 functions to switch power on and off to U6, so that the sine wave can be turned on only while measuring hematocrit. Q2 is in turn switched by optoisolator U14, which is connected to an output port of the processor.

Analog Multiplexer

All of the signals discussed thus far, as well as others, are applied to inputs of the Analog Multiplexer, U10. The function of this device is to select one of these inputs to be applied to the V/F Converter for quantization. The signal to be quantified is selected by a binary address applied to the four address pins on the MUX. These address signals are generated by an output port of the processor section, and isolated by opto-isolators U15, U16, U17, and U18.

Other signals applied to the Analog Multiplexer are 2.500 Volt reference, ground, and a DC. voltage from U7 which indicates heater block temperature. A non-committed input connects to TP10. Test signals are applied to this input during board or system test. The ground and 2.500V inputs are used as calibration signals so that the absolute value of other inputs can be determined.

Low Pass Filter

The output of the Analog Multiplexer is filtered by U4B, a 2-pole, 5Hz low pass filter to remove line and other high frequency noise. The output of this stage is then applied to the V/F Converter.

Voltage to Frequency Converter

This device, U12 digitizes the electrode and other signals. It is actually a current to frequency converter. The output is a pulse train the frequency of which is proportional to the current into pin 1. R63 from the output of the low pass filter sets the voltage to current scale factor. The overall scale factor is approximately 6000Hz/Volt. R62 sets a constant current into the V/F as an offset so that negative voltages of up to (-) 2.5V from the analog section can be accommodated.

The output pulse from U12 is applied to Q3, which drives opto-isolator U13. RV1 sets the drive current to U13. This avoids saturating the output transistor in the isolator, so that the high-frequency pulse train can be passed through.

The output of the opto-isolator is applied to the summing junction of U20. This is done in order to hold the voltage across the transistor in the isolator at O volts, again to keep frequency response high. When RV1 is properly adjusted, the pulse amplitude at TP2 will be 2.8 to 3.0 Volts. The output of U20 is converted to a TTL compatible signal by Q4 and applied to an input port on the processor.

Microprocessor circuitry

This section describes the processor inputs and outputs and touches on the function of each device in the processor section. For a full description of the microprocessor section refer to Rockwell International data books and other 6502 microcomputer publications.

Central Processing Unit

U37 is the CPU, or central processing unit. It is an 8-bit device operating at a system clock period of 1.085 micro-second. This device is the "brains" of the system, fetching and executing instructions from ROM, storing and retrieving data from RAM, and inputting and outputting data and control signals from the I/O ports.

The NMI (non-maskable interrupt) input at pin 6 connects to the power monitor on the power supply assembly. This input will go low if power should fail for any reason. In response, the processor executes a short series of instructions which allow the system to recover after power restoration if a cartridge is installed at the time of power interruption.

The RES (reset) input at pin 40 is driven by Q8, which is also connected to the power monitor on the power supply assembly. Q8 is pulsed on, pulling the RES input low, for several milliseconds after power is turned on. Reset is also applied a few milliseconds after a power failure is detected.

Read-Only Memory (ROM)

U31, U32 and U36 comprise the system ROM. Each of these devices is a 16K by 8 EPROM. ROM occupies the upper 32K address space. These devices are programmed at the factory with the current version of the operating system, which is marked on each.

Random-Access Memory (RAM)
U35 has 8K of Static RAM used to store sample data, time information and other variable data. This device is battery-backed with on-board battery B1, so that data can be retained during a power outage. The device enables signals at pin 20 is gated by transistor Q6. The base drive to Q6 is removed when RESET is applied, insuring that data in RAM is protected during the period of time that the power supply voltages are falling after a power fail.

RS-232 Port
The RS-232 port is interfaced to the system bus by RS-232 to TTL level shifters U44 and U45, and UART (Universal Asynchronous Receiver Transmitter) U43, which sets the Baud rate, establishes the data byte format and performs the serial/parallel conversions and data transmission and reception. See Appendix 3, "RS-232 Communication Specifications" for details regarding output signals.

Address Bus Decoder
U34 is a Programmable Array Logic Device (PAL) that decodes the system address bus to form individual Chip Enable signals for the other devices connected to the data bus. The logic pattern in this device establishes the system memory map. Additional logic was necessary to develop the enable signals for U25 and U29.

Motor Control Signals
The control signals for the pump and valve motors are derived from Port B of U27, which generates an enable signal for each motor, and common rate and direction signals. The stepper motor drive-circuits on the power supply assembly require high-level 12 volt logic signals. U38 and U39 shift the TTL level outputs of U27 to 12V logic levels and separate the common rate signal to individual rate signals for each stepper motor. The function of each line is:

P2 PIN#	LABEL	FUNCTION
10	DIR	Common direction signal
43	CVRT	Cartridge Valve Motor Rate
44	PRT	Pump Rate (No longer used)
46	PEN	Pump Enable (Low = on)
21	ARRT	Not used
20	AREN	Door Lock Solenoid (High = on)
8	VRT	Not used
11	VEN	Cartridge Enable Solenoid (High = enable)

Printer Interface
The printer is driven from Port A of U27. A standard Centronics interface is implemented. The INIT signal at pin of P3 connects to the system reset signal and initializes the logic on the printer control board. The FEED signal at pin 29 connects to the Paper Feed key on the keyboard.

Display Control

All logic signals required to control the displays are developed from Ports A and B of U28.

Light Emitting Diode (LED) Control

The LED on the front panel illuminates the ENTER keypad and is controlled by U29 which is used as a dedicated output port on the processor bus. The output of U29 controls the signal LED on the front panel.

Keyboard Interface

The keyboard is a matrix of contacts on a 5 row by 4 column grid. U30 is a keyboard scanning device that applies pulses to the column lines and detects a closure on the row lines. When a key closure is detected, the DA output interrupts the processor through the CA2 input of U28. A unique key code is placed on the data bus. C45 establishes the scan rate, and C46 sets the key debounce period.

System Status Signals

U25 is a latch connected as an 8-bit input port to the processor. The processor frequently samples this port to obtain Status information. The function of each of these lines is:

P2 PIN#	LABEL	FUNCTION
30	CART	Low when cartridge is installed.
31	HOLE	Output of the reflective sensor on the Inner Wall assembly used to detect rotor position. Should be high after a rotor index operation.
32	HOME CV	Low when Cartridge Control Arm is at the B position.
24	LATCH	Low when door is latched.

System Real Time Calendar Clock

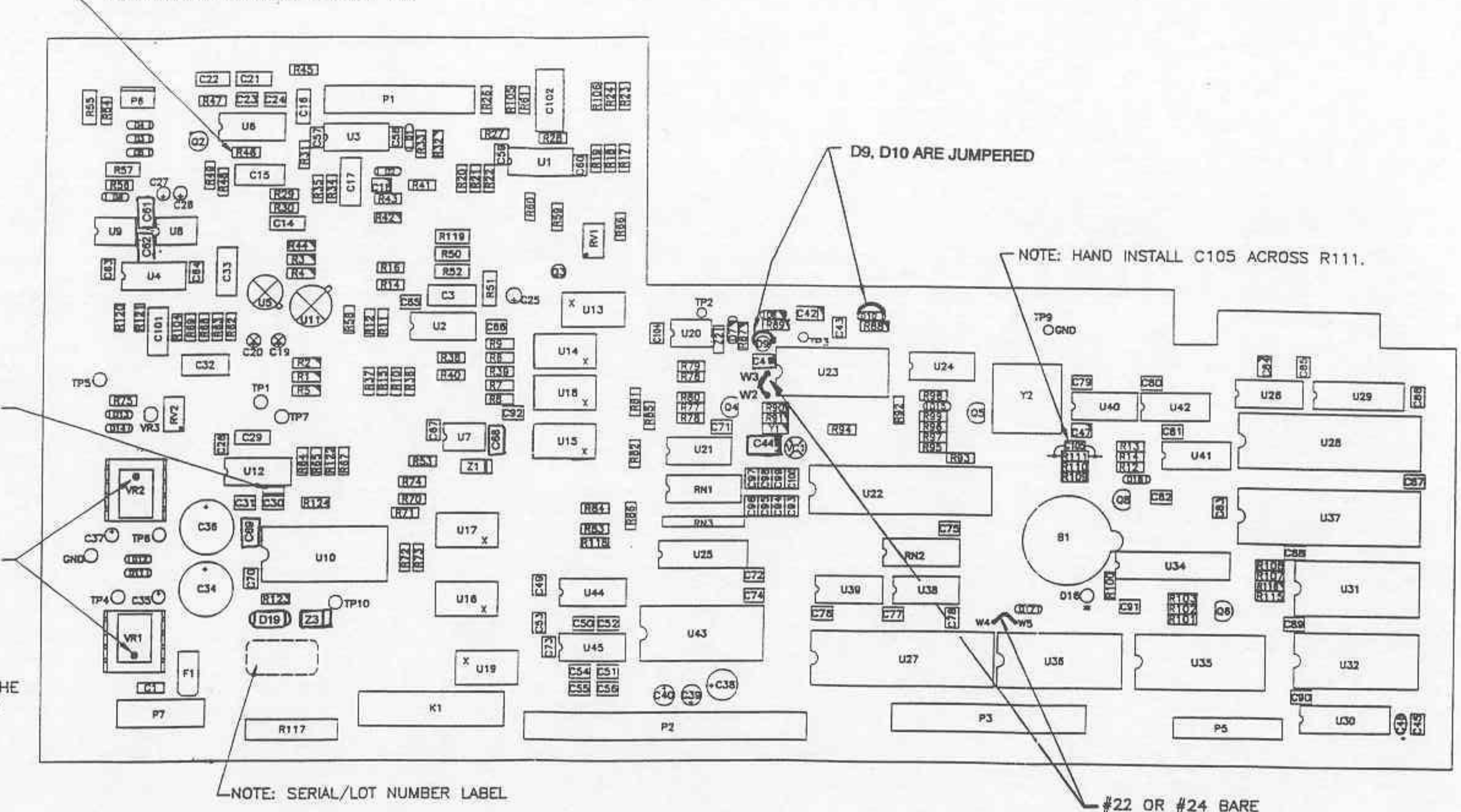
Because of the need to maintain time and date for cartridge life tracking and data reporting, a battery backed clock integrated circuit (U23) is interfaced to the processor through Port A of U22. Time and date information are entered on the keyboard and stored in the clock by the processor. The clock circuit maintains time and date for 5 - 7 years and requires resetting only in case of battery failure or to accommodate daylight savings time. Leap years are accounted for.

To conserve battery power, Q5 and U24 form a circuit that place the clock in a standby mode when A-C power is off. When power fails, Q5 turns off. Pin 2 of U24 is then pulled low, driving the *CS input high and the *STBY pin low.

Opto-Isolator and Solid State Relay Drive

Port B of U22 is controls the solid State relay and opto-isolators which control the operation of the analog section. An open collector inverter device, U21, is used because these devices require more drive current than the I/O device U22 can supply.

NOTE: 36K IS THE NOMINAL VALUE. THIS PART MAY BE BETWEEN 20K AND 51K


P1
P2
P3
P5
P6
P7
K1
R117
F1
B1
Y2
VR1
VR2
VR3
RV1
RV2
RN1
RN2
RN3
U1
U2
U3
U4
U6
U7
U8
U9
U10
U12
U13
U14
U15
U16
U17
U18
U19
U20
U21
U22
U23
U24
U25
U26
U27
U28
U29
U30
U31
U32
U34
U35
U36
U37
U38
U39
U40
U41
U42
U43
U44
U45
C3
C14
C15
C17
C29
C32
C33
C34
C36
C101
C102
TP1
TP2
TP4
TP5
TP6
TP7
TP9
TP10
GND
W2
W3
W4
W5
D16
D19
Z1
Z3
Q2
Q4
Q5
Q6
Q8

D9, D10 ARE JUMPERED

NOTE: HAND INSTALL C105 ACROSS R111.

C106 65531010 100 pfd
INSTALL ON BACK SIDE IF
REQUIRED

10270002 SCREW #4—40
X 3/8 (2) REQ'D
950005 FLATWASHER #4
(2) REQUIRED
830004 KEPS NUT #4—40
(2) REQUIRED

—APPLY A THIN FILM OF HEATSINK COMPOUND TO THE UNDERSIDE OF VR1 & VR2 BEFORE MOUNTING.

NOTE: SERIAL/LOT NUMBER LABEL

#22 OR #24 BARE JUMPER WIRE

(FROM W2 TO W3) &
(FROM W4 TO W5)

NOTES:

COMPONENTS NOT INSTALLED:	RECENT CHANGES - PARTS REMOVED:
R1-5, R32, R42, R44, R87-89, R116.	R90, R91
U5, U11.	Y1
C18, C42, C47, C84.	C44
D7, D8, D9, D10.	VC1
C19, C20	

Fig. 8-4, A/D Board (MSS # 480006)

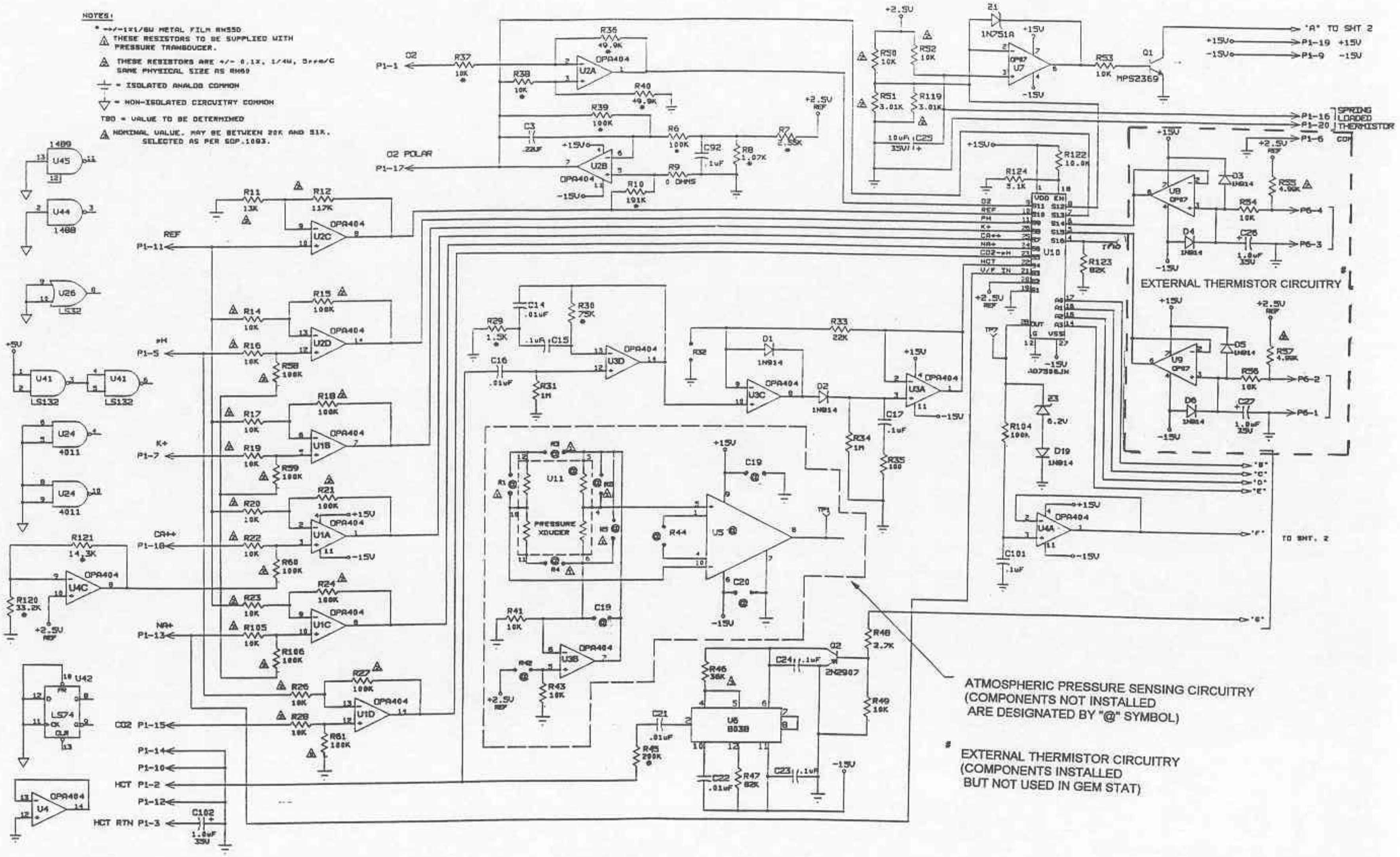

NOTES:
* +/-1%1/8W METAL FILM RN55D
THESE RESISTORS TO BE SUPPLIED WITH PRESSURE TRANSDUCER.
THESE RESISTORS ARE +/- 0.1%, 1/4W, 5ppm/C SAME PHYSICAL SIZE AS RN60
= ISOLATED ANALOG COMMON
= NON-ISOLATED CIRCUITRY COMMON
TBD = VALUE TO BE DETERMINED
NOMINAL VALUE. MAY BE BETWEEN 20K AND 51K. SELECTED AS PER SOP.1083.
ATMOSPHERIC PRESSURE SENSING CIRCUITRY (COMPONENTS NOT INSTALLED ARE DESIGNATED BY "@" SYMBOL)
# EXTERNAL THERMISTOR CIRCUITRY (COMPONENTS INSTALLED BUT NOT USED IN GEM STAT)
EXTERNAL THERMISTOR CIRCUITRY
PRESSURE XDUCER
U11
U5
U6 8038
U10
AD7506JN
VDD EN
S11 S10 S9 S8 S7 S6 S5 S4 S3 S2 S1
S12 S13 S14 S15 S16
A0 A1 A2 A3
OUT G VSS
O2
REF
PH
K+
CA++
NA+
CO2-pH
HCT
V/F IN
P1-1
P1-17
O2 POLAR
P1-11
P1-5
pH
P1-7
K+
P1-18
CA++
P1-13
NA+
CO2 P1-15
P1-14
P1-10
HCT P1-2
P1-12
HCT RTN P1-3
'A' TO SHT 2
+15V
-15V
P1-19 +15V
P1-9 -15V
P1-16
P1-20
P1-6
SPRING LOADED THERMISTOR
COM
P6-4
P6-3
P6-2
P6-1
'B'
'C'
'D'
'E'
'F'
'G'
TO SHT. 2
+2.5V REF
TP1
TP6
TP7
OPA404
OP97
U2A U2B U2C U2D
U1A U1B U1C U1D
U3A U3C U3D
U4 U4A U4C
U7 U8 U9
U24 4011
U41 LS132
U44 1488
U45 1489
U26 LS32
U42 LS74
Q1 MPS2369
Q2 2N2907
Z1 1N751A
Z3 6.2V
D1 D2 D3 D4 D5 D6 D19 1N914
R11 13K
R12 117K
R14 10K
R15 100K
R16 10K
R17 10K
R18 100K
R19 10K
R20 10K
R21 100K
R22 10K
R23 10K
R24 100K
R26 10K
R27 100K
R28 10K
R29 1.5K
R30 75K
R31 1M
R32
R33 22K
R34 1M
R35 49.9K
R37 10K
R38 10K
R39 100K
R40 49.9K
R41 10K
R43 10K
R44
R45 200K
R46 36K
R47 82K
R48 2.7K
R49 10K
R50 10K
R51 3.01K
R52 10K
R53 10K
R54 10K
R55 4.99K
R56 10K
R57 4.99K
R58 100K
R59 100K
R6 100K
R7 2.55K
R8 1.07K
R9 0 OHMS
R10 191K
R61 100K
R68 100K
R104 100K
R105 10K
R106 100K
R119 3.01K
R120 33.2K
R121 14.3K
R122 10.0K
R123 82K
R124 5.1K
C3 .22uF
C14 .01uF
C15 .1uF
C16 .01uF
C17 .1uF
C19
C20
C21 .01uF
C22 .01uF
C23 .1uF
C24 .1uF
C25 10uF 35V
C26 1.0uF 35V
C27 1.0uF 35V
C92 .1uF
C101 .1uF
C102 1.0uF 35V
+5V

Fig. 8-5, A/D Board (MSS# 480006) Schematic (1 of 3)

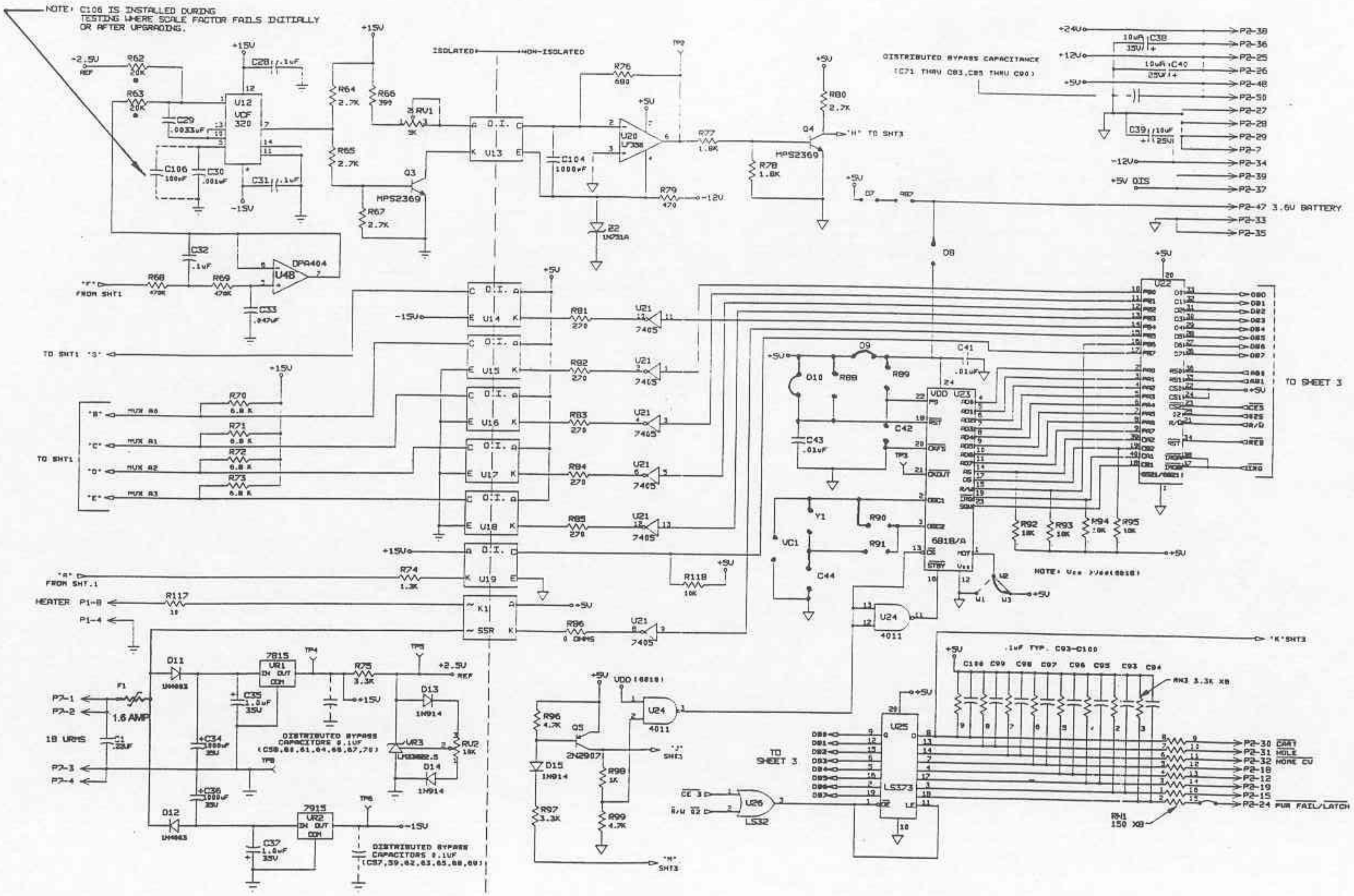

NOTE: C106 IS INSTALLED DURING TESTING WHERE SCALE FACTOR FAILS INITIALLY OR AFTER UPGRADING.
-2.5V REF
R62 20K
R63 20K
C29 .0033uF
C106 100pF
C30 .001uF
U12 VCF 320
C28 .1uF
C31 .1uF
+15V
-15V
R64 2.7K
R66 390
RV1 5K
R65 2.7K
Q3 MPS2369
R67 2.7K
ISOLATED
NON-ISOLATED
O.I. U13
C104 1000pF
R76 680
U20 LF398
R77 1.8K
R79 470
-12V
Z2 1N751A
TP2
Q4 MPS2369
R80 2.7K
R78 1.8K
'H' TO SHT3
DISTRIBUTED BYPASS CAPACITANCE (C71 THRU C83, C85 THRU C90)
+24V
+12V
+5V
C38 10uF 35V
C40 10uF 25V
C39 10uF 25V
-12V
+5V DIS
P2-38
P2-36
P2-25
P2-26
P2-48
P2-50
P2-27
P2-28
P2-29
P2-7
P2-34
P2-39
P2-37
P2-47 3.6V BATTERY
P2-33
P2-35
D7
D8
C32 .1uF
U48 OPA404
C33 .047uF
R68 470K
R69 470K
'F' FROM SHT1
U14
U15
U16
U17
U18
U19
TO SHT1 'G'
R70 6.8K
R71 6.8K
R72 6.8K
R73 6.8K
MUX A0
MUX A1
MUX A2
MUX A3
'B'
'C'
'D'
'E'
TO SHT1
R81 270
R82 270
R83 270
R84 270
R85 270
U21 7405
R74 1.3K
'A' FROM SHT.1
HEATER P1-8
P1-4
R117 10
K1 SSR
R86 0 OHMS
R118 10K
D9
D10
R88
R89
C41 .01uF
C42
C43 .01uF
TP3
U23 6818/A
Y1
VC1
R90
R91
C44
U24 4011
R92 10K
R93 10K
R94 10K
R95 10K
NOTE: Vcc >Vdd(6818)
W1
W2
W3
U22
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
AB0
AB1
CE5
CE26
R/D
RES
IRQ
TO SHEET 3
'K' SHT3
D11 1N4003
D12 1N4003
F1 1.6 AMP
C1 .22uF
P7-1
P7-2
18 VRMS
P7-3
P7-4
7815 VR1
7915 VR2
C35 1.0uF 35V
C34 1000uF 35V
C36 1000uF 35V
C37 1.0uF 35V
TP4
TP5
TP6
TP8
R75 3.3K
+2.5V REF
D13 1N914
D14 1N914
VR3 LM336Z-2.5
RV2 10K
DISTRIBUTED BYPASS CAPACITORS 0.1uF (C58,60,61,64,66,67,70)
DISTRIBUTED BYPASS CAPACITORS 0.1uF (C57,59,62,63,65,68,69)
VDD (6818)
R96 4.7K
Q5 2N2907
D15 1N914
R97 3.3K
R98 1K
R99 4.7K
'J' SHT3
'M' SHT3
TO SHEET 3
U26 LS32
U25 LS373
.1uF TYP. C93-C100
RN3 3.3K X8
RN1 150 X8
P2-30 CNT
P2-31 HOLE
P2-32 HOME CV
P2-18
P2-12
P2-19
P2-15
P2-24 PWR FAIL/LATCH

Fig. 8-6, A/D Board (MSS# 480006) Schematic (2 of 3)

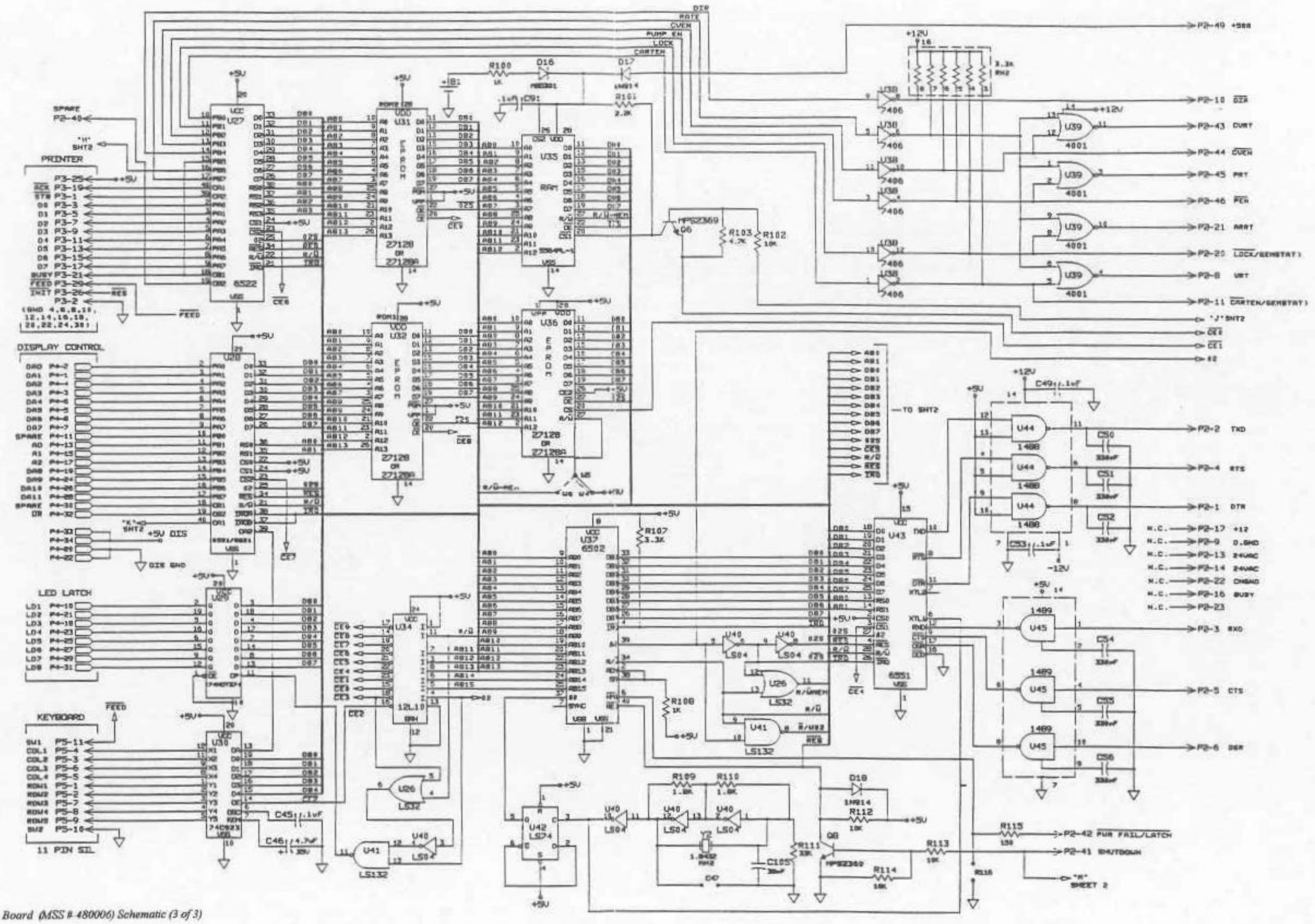

PRINTER
DISPLAY CONTROL
LED LATCH
KEYBOARD
11 PIN SIL
SPARE P2-40
U27
6522
U28
U29
U30
74C923
U31
EPROM
27128 OR 27128A
U32
U33
RAM
U35
U36
U34
12L10
U37
6502
U40
LS04
U26
LS32
U41
LS132
U42
LS74
U43
6551
U44
1488
U45
1489
U38
7406
U39
4001
Q6
MPS2369
Q8
MPS2369
R100
R101
R102
R103
R107
R108
R109
R110
R111
R112
R113
R114
R115
R116
D16
D17
D18
C45
C46
C49
C50
C51
C52
C53
C54
C55
C56
C91
C105
+5V
+12V
-12V
P2-49 +5RB
P2-10 DIR
P2-43 OVRT
P2-44 OVEN
P2-45 PRT
P2-46 FEN
P2-21 ARRT
P2-25 LOCK/SENSTAT
P2-8 VRT
P2-11 CARTEN/SENSTAT
"J" SHT2
TO SHT2
P2-2 TXD
P2-4 RTS
P2-1 DTR
P2-17 +12
P2-9 D.GND
P2-13 24VAC
P2-14 24VAC
P2-22 CHGND
P2-16 BUSY
P2-23
P2-3 RXD
P2-5 CTS
P2-6 DSR
P2-42 PWR FAIL/LATCH
P2-41 SHUTDOWN
"H" SHEET 2
DTR
RATE
OVEN
PUMP EN
LOCK
CARTEN
FEED

Fig. 8-7. A/D Board (MSS # 480006) Schematic (3 of 3)

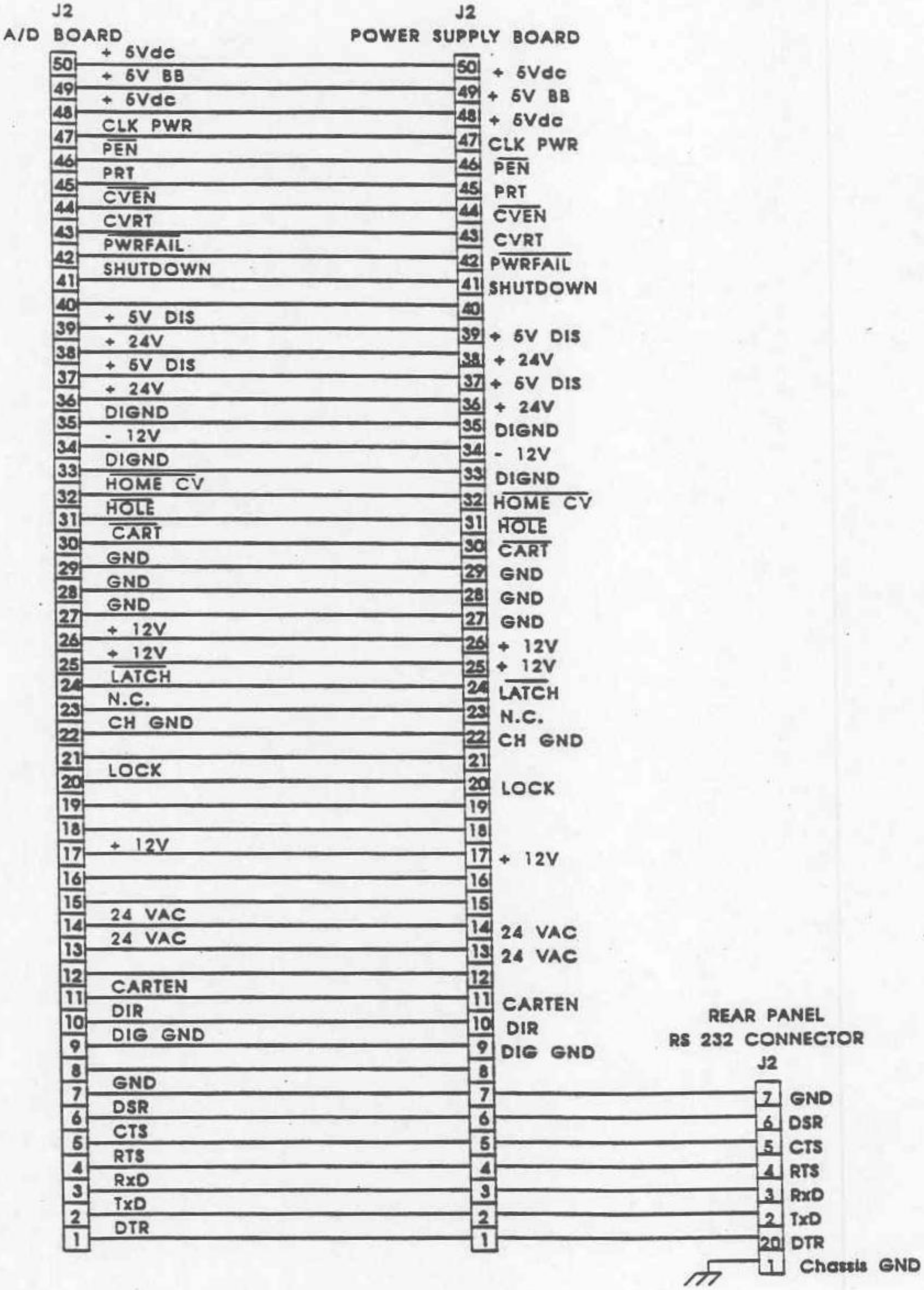

J2
A/D BOARD
J2
POWER SUPPLY BOARD
+ 5Vdc
+ 5V BB
+ 5Vdc
CLK PWR
PEN
PRT
CVEN
CVRT
PWRFAIL
SHUTDOWN
+ 5V DIS
+ 24V
+ 5V DIS
+ 24V
DIGND
- 12V
DIGND
HOME CV
HOLE
CART
GND
GND
GND
+ 12V
+ 12V
LATCH
N.C.
CH GND
LOCK
+ 12V
24 VAC
24 VAC
CARTEN
DIR
DIG GND
GND
DSR
CTS
RTS
RxD
TxD
DTR
REAR PANEL
RS 232 CONNECTOR
J2
7 GND
6 DSR
5 CTS
4 RTS
3 RxD
2 TxD
20 DTR
1 Chassis GND

Fig. 8-8, Main Harness Schematic

Parts List for A/D board

FIG.	QTY	MSS PART #	LOCATION	DESCRIPTION
8-6	2	10270002	VR1,VR2	SCREW, 4-40X3/8 HD, BLACK
8-6	1	31052010	R117	RESISTOR, W.W., 5W, 5%,10 OHM.
8-5	2	34043301	R51, R119	RESISTOR, MF, 1/4W, 0.1%,3.01K
8-5	2	34043499	R55, R57	RESISTOR,UP,MF,1/4W, 0.1%,4.99K
8-5	12	34044100	R14, R16, R17, RI9, R20, R22, R23, R26, R28, R50, R52, R105	RESISTOR, MF,1/4W,0.1%,10K
8-5	1	34044130	R11	RESISTOR, UP,MF,1/4W,0.1%,13.0K
8-5	10	34045100	R15, R18, R21, R24, R27, R58, R59, R60, R61, R106	RESISTOR,UP,MF1/4W,0.1%100K
8-5	1	34045117	R12	RESISTOR,UP,MF,1/4W,0.1%,117K
8-5	1	34103107	R8	RESISTOR,MF,1/8W,1%,1.07K
8-5	1	34103150	R29	RESISTOR,MF125W,1%,1.50K
8-5	1	34103255	R7	RESISTOR, MF,1/8W,1%,2.55K
8-5	2	34104100	R37, R38	RESISTOR, MF,.125W,1%,10K
8-5	1	34104143	R121	RESISTOR, MF,.125W,1%,14.3K
8-6	2	34104200	R62, R63	RESISTOR, MF,1/8W,1%,20K
8-5	1	34104332	R120	RESISTOR, MF,1/8W,1%,33.2K
8-5	2	34104499	R36, R40	RESISTOR, CF,1/8W,1%,49.9K
8-5	1	34104750	R30	RESISTOR, MF,.125W,1%,75.0K
8-5	2	34105100	R6, R39	RESISTOR, MF,.125W,1%,100K
8-5	1	34105191	R10	RESISTOR, MF,1/8W,1%,191K
8-5	1	34105200	R45	RESISTOR, MF,1/8W,1%,200K
8-5	1	34452000	R9	RESISTOR, CF,1/4W,5%,0 OHM.
8-6	1	34452000	R86	RESISTOR, CF,1/4W,5%,0 OHM.
8-5	1	34452100	R35	RESISTOR, CC,1/4W,5%,100 OHM.
8-7	1	34452150	R115	RESISTOR,CC-CF,1/4W,5%,150 OHM.
8-6	5	34452270	R81-R85	RESISTOR, CF,1/4W,5%,270 OHM.
8-6	1	34452390	R66	RESISTOR,CF,1/4W,,5%,390 OHM.
8-6	1	34452470	R79	RESISTOR,CF,1/4W,5%,470 OHM.
8-6	1	34452680	R76	RESISTOR,CC,.25W,5%,680 OHM.
8-6	1	34453100	R98	RESISTOR,CC,1/4W,5%,1K
8-7	2	34453100	R100, R108	RESISTOR,CC,1/4W,5%,1K
8-6	1	34453130	R74	RESISTOR,CF,1/4W,5%,1.3K
8-6	2	34453180	R77, R78	RESISTOR,CF,1/4W,5%,1.8K
8-7	2	34453180	R109, R110	RESISTOR,CF,1/4W,5%,1.8K
8-7	1	34453220	R101	RESISTOR,CF,1/4W,5%,2.2K
8-5	1	34453270	R48	RESISTOR,CF,1/4W,5%,2.7K
8-6	4	34453270	R64, R65, R67, R80	RESISTOR,CF,1/4W,5%,2.7K

FIG.	QTY	MSS PART #	LOCATION	DESCRIPTION
8-6	2	34453330	R75, R97	RESISTOR,CF,1/4W,5%,3.3K
8-7	1	34453330	R107	RESISTOR,CF,1/4W,5%,3.3K
8-6	2	34453470	R96, R99	RESISTOR,CF,1/4W,5%,4.7K
8-7	1	34453470	R103	RESISTOR,CF,1/4W,5%,4.7K
8-5	1	34453510	R124	RESISTOR,CF,1/4W,5%,5.1K
8-6	4	34453680	R70-73	RESISTOR,CF,1/4W,5%,6.8K
8-5	7	34454100	R41, R43, R49, R53, R54, R56, R122.	RESISTOR,CF,1/4W,5%,10K
8-6	5	34454100	R92-95, R118	RESISTOR,CF,1/4W,5%,10K
8-7	4	34454100	R102, R112-114.	RESISTOR,CF,1/4W,5%,10K
8-5	1	34454220	R33	RESISTOR,CF,1/4W,5%,22K
8-7	1	34454330	R111	RESISTOR,CF,1/4W,5%,33K
8-5	1	34454360	R46	RESISTOR,CC OR CF,1/4W,5%,36K
8-5	2	34454820	R47, R123	RESISTOR,CF,1/4W,5%,82K
8-5	1	34455100	R104	RESISTOR,CF,1/4W,5%,100K
8-6	2	34455470	R68,R69	RESISTOR,CF,1/4W,5%,470K
8-5	2	34456100	R31, R34	RESISTOR,CF,1/4W,5%,1 MEG.
8-6	1	36482150	RN1	RESISTOR,NETWORK,DIP, (150 X 8)
8-7	1	36483330	RN2	RESISTOR,NETWORK, (3.3K X 8)
8-6	1	36803330	RN3	RESISTOR, NETWORK,SIP, (3.3KX8)
8-6	1	48153500	RV1	TRIMPOT, 5K
8-6	1	48154100	RV2	TRIMPOT, 10K
8-5	1	51501006	C102	CAP., POLY, METAL, 100V, 1MF
8-5	1	51502208	C3	CAP., 100VDC, 0.22MF
8-5	2	51511007	C15, C17	CAP., 100VDC, 5%, 0.1MF
8-5	4	54011008	C14, C16, C21, C22	CAP., 400VDC, 5%, 0.01MF
8-6	1	56303303	C29	CAP., 630V, .0033MF
8-4	1	620001	N/A	PC BOARD, ANALOG/DIGITAL
8-6	2	65501009	C30, C104	CAP.,CERAMIC, 1000PF, 50V
8-7	6	65503310	C50, C51, C52, C54-56.	CAP., 50V, CERAMIC, 330PF
8-5	3	65521007	C23, C24, C92	CAP., 50V, CERAMIC, 0.1MF
8-6	43	65521007	C28, C31, C57-83, C85-90, C93-100.	CAP., 50V, CERAMIC, 0.1MF
8-7	4	65521007	C45, C49, C53, C91.	CAP., 50V, CERAMIC, 0.1MF
8-5	2	65521008	C41,43	CAP.,50V, CERAMIC, 0.01MF
8-6	1	65542208	C1	CAP., MONO, CERAMIC,100V,0.22MF
8-7	1	65553911	C105	CAP., CERAMIC, 1000V, 39PF
8-7	1	660063	U34	PROGRAMED LOGIC ARRAY (PAL)
8-7	1	693031	P5	CONN., 11 PIN, SEC. PROCESS
8-6	2	700020	VR1, VR2	HEAT SINK
8-6	2	70261005	C39, C40	CAP., 25V, 10MF, TANTALUM

FIG.	QTY	MSS PART #	LOCATION	DESCRIPTION
8-5	1	70351005	C25	CAP., 35V, 10MF, TANTALUM
8-6	1	70351005	C38	CAP., 35V, 10MF, TANTALUM
8-5	2	70351006	C26, C27	CAP., 35V, 1.0MF, TANTALUM
8-6	2	70351006	C35, C37	CAP., 35V, 1.0MF, TANTALUM
8-7	1	70354706	C46	CAP., 35V, 4.7MF, ELEC., TANTALUM
8-7	1	740016	U30	DECODER, KEYBOARD(20) KEY
8-5	1	770047	P6	CONN., 4 PIN HEADER, LOCKING
8-6	1	770064	P2	CONN., MALE HEADER (50 PIN)
8-7	1	770067	P3	CONN., MALE HEADER (30 PIN)
8-5	1	770073	P1	CONN., MALE HEADER (20 PIN)
8-6	1	770077	P7	CONN., MALE HEADER (4 PIN)
8-6	2	770142	F1	SOCKET (1 PIN) KNURL MOUNT
8-7	1	790016	B1	BATTERY, LITHIUM, 3.6V
8-6	2	80351003	C34, C36	CAP., 35V, 1000MF, ELECTROLYTIC
8-6	7	810001	U13 -19	INSULSTOR, OPTICAL, UL, CSA,VDE
8-6	2	830004	VR1, VR2	KEPS NUT, 4-40
8-6	1	860024	F1	PTC RESISTANCE DEVICE 1.6 AMP
8-6	1	870002	K1	RELAY, SOLID STATE, UL,CSA,VDE
8-6	2	880001	D11, D12	DIODE, IN4003
8-5	7	880005	D1-6, D19	DIODE, IN914
8-6	3	880005	D13-15.	DIODE, IN914
8-7	2	880005	D17, D18	DIODE, IN914
8-6	1	880007	VR3	DIODE, ZENER, LM336Z
8-7	1	880012	D16	DIODE SHOTTKY
8-5	1	880014	Z1	DIODE, ZENER, 5.1V
8-6	1	880014	Z2	DIODE, ZENER, 5.1V
8-5	1	880018	Z3	DIODE, ZENER, 6.2V, 1%, 1W
8-5	1	884007	Q1	TRANSISTOR, SWITCH, NPN
8-6	4	884007	Q3, Q4, Q6, Q8	TRANSISTOR, SWITCH, NPN
8-5	1	884010	Q2	TRANSISTOR, SWTICH, PNP
8-6	1	884010	Q5	TRANSISTOR, SWTICH, PNP
8-6	1	888004	VR1	REGULATOR, VLT., 15V
8-6	1	888005	VR2	REGULATOR, VLT., -15V
8-6	1	888007	U20	OP. AMP., (LF356)
8-5	1	888012	U10	MULTIPLEXER, ANALOG
8-5	3	888021	U7, U8, U9	OP. AMP., LOW OFFSET DRIFT
8-5	4	888028	U1, U2, U3, U4	OP. AMP., QUAD PRECISION OPA404
8-6	N/A	888028	U4	OP. AMP., QUAD PRECISION OPA404
8-6	1	888029	U12	CONVERTER, V/F, (VFC320)
8-6	1	888051	U23	CLOCK (DS1287) WITH BATTERY
8-7	1	890000	U38	INVERTER, HEX 7406
8-5, 8-6	1	890001	U24	GATE, NAND, (CMOS)
8-6	1	890003	U22	PARALLEL INTERFACE ADAPTER
8-7	1	890003	U28	PARALLEL INTERFACE ADAPTER
8-7	1	890004	U27	VIDEO INETERFACE ADAPTER

FIG.	QTY	MSS PART #	LOCATION	DESCRIPTION
8-6	1	890005	U21	INVERTER, IC, 7405
8-7	1	890007	U37	MICROPROCESSOR
8-5	1	890012	U6	GENERATOR, FUNCTION
8-5, 8-7	1	890013	U44	DRIVER LINE, 1488 TYPE
8-6	1	890014	U25	FLIP-FLOP, OCTAL
8-5, 8-7	1	890015	U42	FLIP-FLOP, DUAL "D"
8-5, 8-6, 8-7	1	890016	U26	GATE, QUAD (PLASTIC)
8-7	1	890017	U39	GATE, NOR, CMOS (PLASTIC)
8-7	1	890019	U29	LATCH, OCTAL, HI-SPEED, CMOS TTI
8-5, 8-7	1	890020	U45	RECEIVER LINE, 1489 TYPE
8-7	1	890021	U43	INTERFACE ADAPTER
8-7	1	890022	U40	INVERTER, HEX 74LS04 TYPE
8-5, 8-7	1	890023	U41	GATE, NAND, 74LS132 TYPE
8-7	3	900004	U31, U32, U36	EPROM OR 900006A, 27128 & 27128A
8-7	1	900005	U35	RAM MEMORY STATIC, CMOS, 8KX8
N/A	16	770009	U1-4, U6, U12, U21, U24, U26, U38-42, U44, U45.	SOCKET DIP, (14 PIN)
N/A	4	770026	U22, U27, U28, U37.	SOCKET DIP, (40 PIN)
N/A	1	770030	U23	SOCKET DIP, (24 PIN)
N/A	6	770031	U10, U31, U32, U35, U36, U43	SOCKET DIP, (28 PIN)
N/A	3	770075	U25, U29, U30	SOCKET DIP, (20 PIN)
N/A	1	770126	U34	SOCKET DIP, (24 PIN) "SKINNEY"
8-7	1	910003	Y2	CRYSTAL, 1.8432MHZ
8-7	N/A	760007	Y2	TAPE, 2 SIDED, 3/4" WIDE
8-6	1	91601007	C32	CAP., 160VDC, 0.1MF, 10%
8-5	1	91601007	C101	CAP., 160VDC, 0.1MF, 10%
8-6	1	91604709	C33	CAP., 160VDC, 0.047MF, 10%
8-6	2	950005	VR1, VR2	FLAT WASHER #4

8.4 DISPLAY CIRCUIT DESCRIPTION

All signals and power necessary to drive the display board are routed through J4 which connects to P4 on the A-D board. The control signals are all derived from I/O device U28 on the A-D board.

The Display Assembly consists of a circuit board containing:

- 7-segment numerical displays for showing blood sample values.
- Intelligent decoder-driver devices for the numeric displays.
- Alphanumeric displays for indicating operating modes, temperature, time, ID numbers, etc.
- Address decoder to provide chip select signals to the alphanumeric displays and numeric display drivers.

Device Select Decoder
IC2 performs the function of decoding the signals "AO", "A1", and "A2" from the A-D board into individual device select signals for the numeric display drivers and the alphanumeric displays.

Numerical Displays and Display Drivers
Blood sample values are displayed on groups of 7-segment displays, which are driven in multiplex manner by the display drivers, N1, N2 and N3. Numerical data to be displayed is written into the appropriate device registers by applying the data in BCD form to DA8, DA9, DA10, and DA11, the digit number (0 to 7) to DA0, DA1, and DA2, and strobbing the *W input on the driver by applying and removing the device address to address decoder IC2.

Intelligent Alphanumeric Display
The alphanumeric display is comprised of three 4-digit intelligent displays stacked end-to-end and yield 12 characters. Alpha numeric data to be displayed is written into the appropriate device registers by applying the data in ASCII form to DA0 through DA6, the digit number (for the individual driver) to DA8 and DA9, the device address (0,1, or 2) to A0, A1 and A2, and strobbing the *WR line.

LED Driver
An LED Latch U29 located on the A-D board drives the open-collector buffer IC3. The IC3 drives the L.E.D. that is used to illuminate the "ENTER" key on the key panel. A resistor sets the current level to the diode.

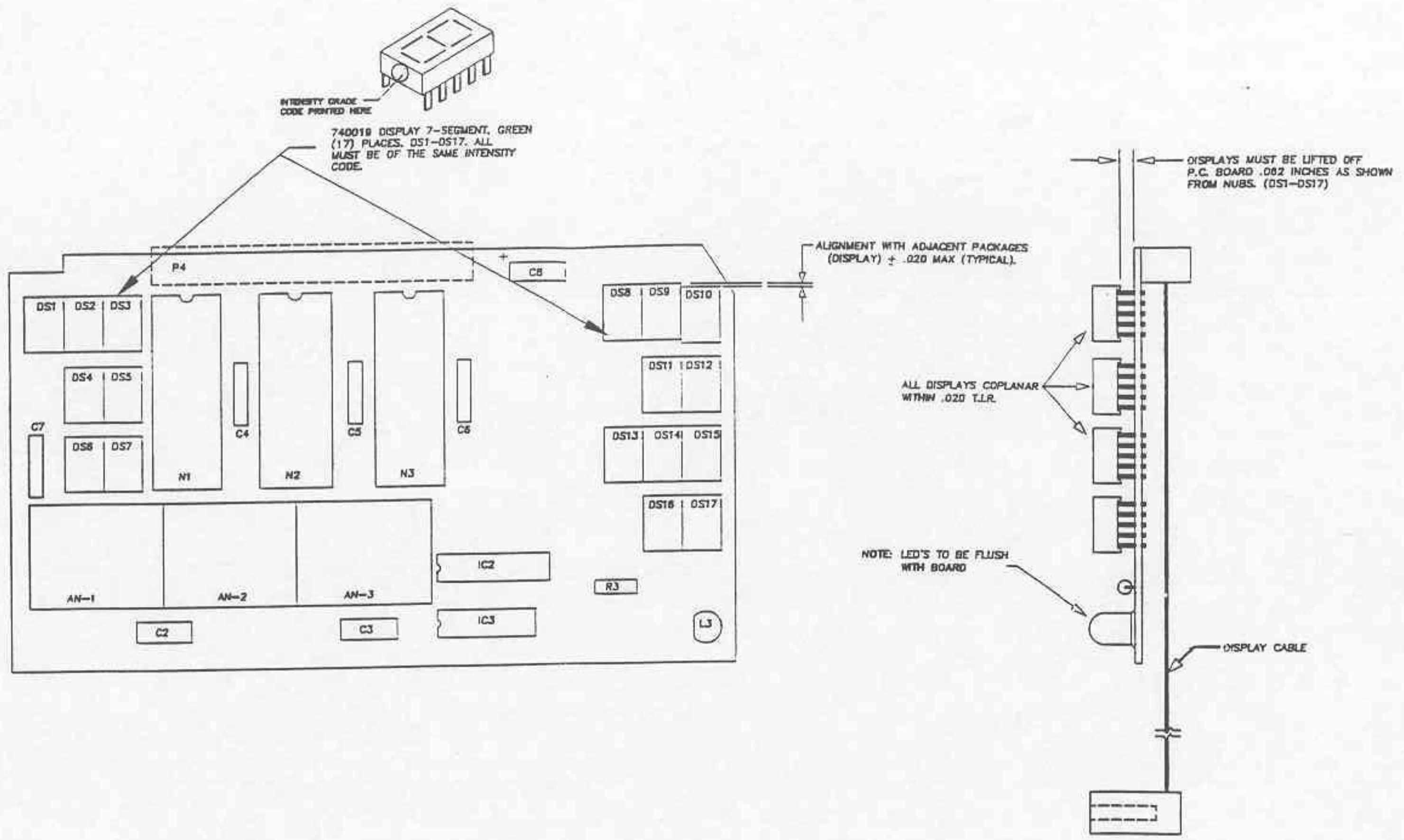

INTENSITY GRADE CODE PRINTED HERE
740019 DISPLAY 7-SEGMENT, GREEN (17) PLACES, DS1-DS17. ALL MUST BE OF THE SAME INTENSITY CODE.
P4
C8
DS1
DS2
DS3
DS4
DS5
DS6
DS7
C7
N1
N2
N3
C4
C5
C6
DS8
DS9
DS10
DS11
DS12
DS13
DS14
DS15
DS16
DS17
AN-1
AN-2
AN-3
IC2
IC3
R3
C2
C3
L3
ALIGNMENT WITH ADJACENT PACKAGES (DISPLAY) ± .020 MAX (TYPICAL).
DISPLAYS MUST BE LIFTED OFF P.C. BOARD .082 INCHES AS SHOWN FROM NUBS. (DS1-DS17)
ALL DISPLAYS COPLANAR WITHIN .020 T.I.R.
NOTE: LED'S TO BE FLUSH WITH BOARD
DISPLAY CABLE

Fig. 8-9, Display Board (MSS #500023)

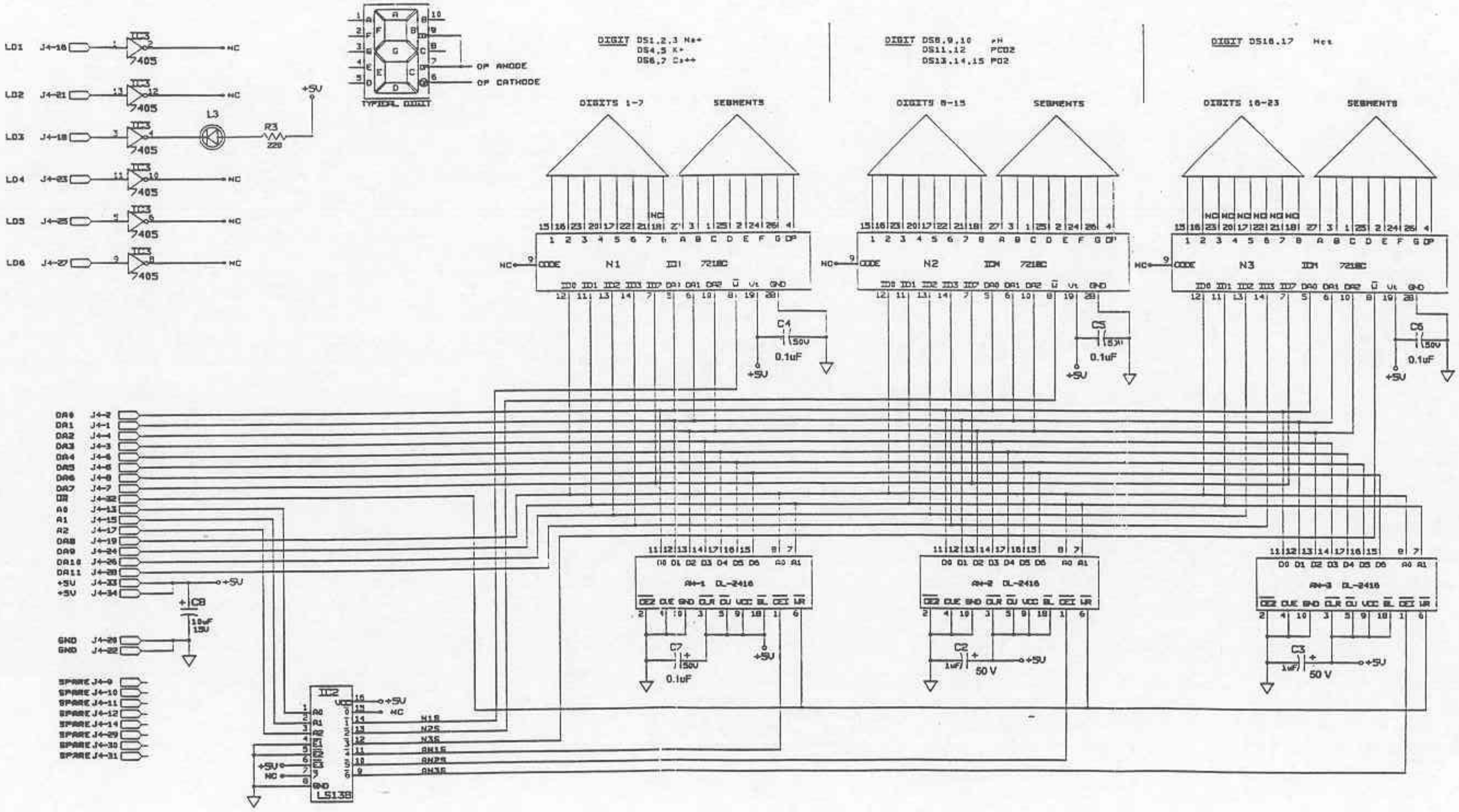

LD1 J4-16
LD2 J4-21
LD3 J4-18
LD4 J4-23
LD5 J4-25
LD6 J4-27
IC3
7405
NC
L3
R3
220
+5V
TYPICAL DIGIT
DP ANODE
DP CATHODE
DIGIT DS1,2,3 Na+
DS4,5 K+
DS6,7 Ca++
DIGIT DS8,9,10 pH
DS11,12 PCO2
DS13,14,15 PO2
DIGIT DS16,17 Hct
DIGITS 1-7
DIGITS 8-15
DIGITS 16-23
SEGMENTS
N1
N2
N3
ID1
ID4
7218C
CODE
C4
C5
C6
0.1uF
50V
DA0 J4-2
DA1 J4-1
DA2 J4-4
DA3 J4-3
DA4 J4-6
DA5 J4-5
DA6 J4-8
DA7 J4-7
WR J4-32
A0 J4-13
A1 J4-15
A2 J4-17
DA8 J4-19
DA9 J4-24
DA10 J4-26
DA11 J4-28
+5V J4-33
+5V J4-34
C8
10uF
15V
GND J4-20
GND J4-22
SPARE J4-9
SPARE J4-10
SPARE J4-11
SPARE J4-12
SPARE J4-14
SPARE J4-29
SPARE J4-30
SPARE J4-31
IC2
LS138
VCC
GND
N1S
N2S
N3S
AN1S
AN2S
AN3S
AN-1 DL-2416
AN-2 DL-2416
AN-3 DL-2416
C7
C2
C3
1uF
50 V

Fig 8-10. Display Board (MSS # 500023) Schematic

Parts List for Display Board Assembly

QTY	MSS PART #	LOCATION	DESCRIPTION
1	34452220	R3	RESISTOR, 1/4W, 5%, 220 OHM
1	560002	N/A	DISPLAY BOARD CABLE
1	600027	N/A	DISPLAY PRINTED CIRCUIT BOARD
1	695152	N/A	DISPLAY BOARD SPACER
4	60501007	C4-7	CAP., 50V, 0.1 MF
1	70151005	C8	CAP., TANTALUM,15V, 10 MF
2	70501006	C2, C3	CAP., TANTALUM, 50V, 1 MF
3	740002	AN1-3	ALPHA NUMERIC DISPLAY
17	740019	DS1-17	7-SEGMENT DISPLAY CHIP
1	740025	L3	LED, GREEN, HI INTENSITY
1	890005	IC3	INVERTER - 7405
1	890008	IC2	DECODER
3	890010	N1-3	DRIVER, ALPHA NUMERIC DISPLAY

8.5 PRINTER ELECTRONICS DESCRIPTION

The printer assembly consists of a thermal printer and control board mounted to a frame which also supports the paper spool.

The control board accepts data to be printed from the A-D board in ASCII form. It converts this data to the dot drive and paper feed signals for the print-head and paper drive motor. A standard Centronics interface is used.

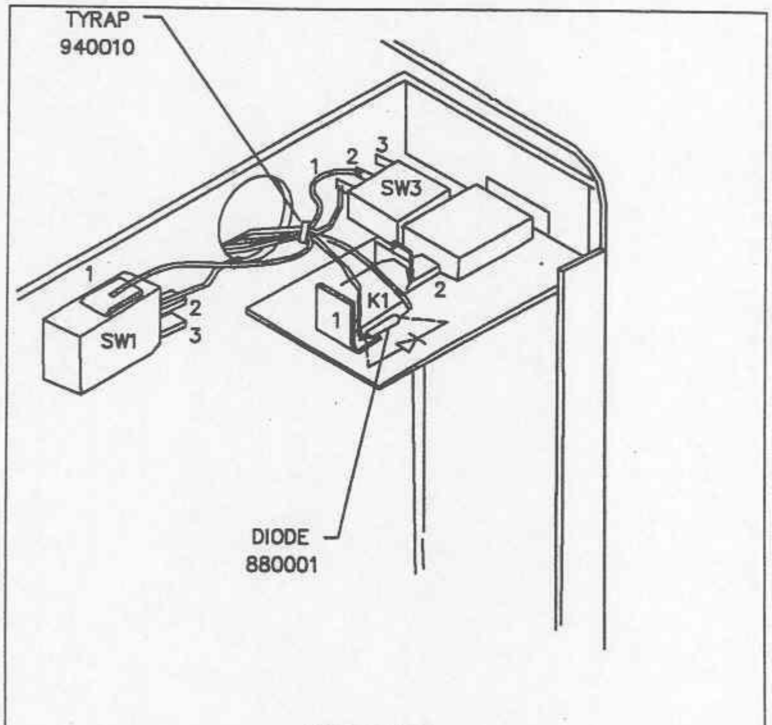
The printer and control board are standard devices purchased by Mallinckrodt Sensor Systems. The manufacturer does not supply detailed technical information. Defective units are shipped "as a set" to the manufacturer for repair.

8.6 DOOR LOCK & CARTRIDGE ENABLE SOLENOIDS & SOLENOID DRIVER BOARD

When a cartridge is installed and the door is closed and latched, the Door Lock Solenoid (K1) is energized and locks the door. This prevents the operator from opening the door, which would make the cartridge unusable. The door is unlocked when the system goes to "REMOVE CART" or the "REMOVE CART" option of the menu is selected. Door Lock Switch (SW3) is tripped when (K1) is energized to close the feedback loop.

The Cartridge Enable Solenoid (K2) prevents the insertion of a cartridge when the system is not prepared to accept one. When (K2) is de-energized, the plunger protrudes into the cartridge compartment and prevents cartridge insertion. When the system goes to "INSERT CART", (K2) is energized and pulls in the plunger in allowing a cartridge to be inserted.

Transistor Q1 on the Solenoid Driver Board controls the Cartridge Enable solenoid (K2), and is driven by the "CARTEN" signal at P1-6, J6-6. Transistor Q2 drives the Door Lock solenoid (K1), and is driven by the "LOCK" signal at P1-5, J6-5. Both solenoids are powered by (+) 24VDC, at P1-2, from the power supply. The signals "CARTEN" and "LOCK" come from U27 on the A/D Board.



WIRE LIST

FROM	TERM	WIRE COLOR	TERM	TO
INNERWALL SW1–1	—	BLK	SOLDER	SW3–1
INNERWALL	—	RED	SOLDER	SW3–2
INNERWALL	—	YEL	SOLDER	K1–1
D1 CATHODE	SOLDER DIODE 880001 D1 BETWEEN K1–1 & K1–2			D1 ANODE
K1–2	SOLDER	GRN	—	INNERWALL

Fig. 8-11, SW1, SW3 and K1 Wiring Diagram

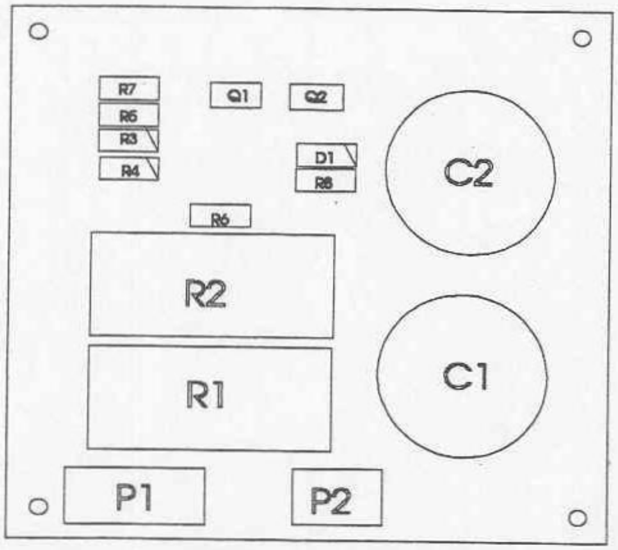

R7
R5
R3
R4
Q1
Q2
D1
R8
R6
C2
R2
R1
C1
P1
P2

Fig. 8-12, Solenoid Driver PCB layout (R3,R4, D1 not installed)

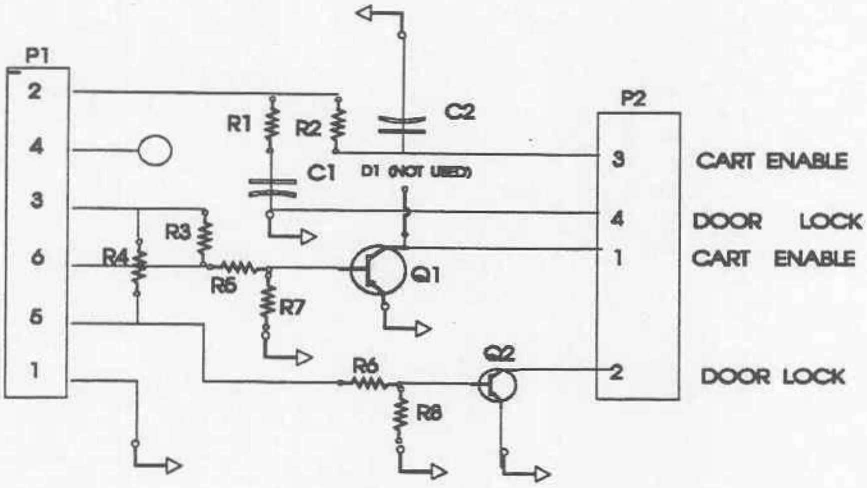

P1
2
4
3
6
5
1
R1
R2
C2
C1
D1 (NOT USED)
R3
R4
R5
R7
Q1
R6
R8
Q2
P2
3
4
1
2
CART ENABLE
DOOR LOCK
CART ENABLE
DOOR LOCK

Fig. 8-13, Solenoid Driver Board Schematic (Components designated with "" are not installed).*

Parts List for Solenoid Driver Board

QTY	MSS PART #	LOCATION	DESCRIPTION
2	31052200	R1, R2	RESISTOR,WW,5W,5%, 200 OHM
2	34453100	R5, R6	RESISTOR, CARB COMP., 1/4W, 5%, 1 K
2	34453470	R7, R8	RESISTOR, 1/4W, 5%, 4.7 K
1	600029	N/A	SOLENOID DRIVER PCB
1	770047	P2	CONNECTOR, 4 PIN HEADER
1	770135	P1	CONNECTOR, 6 PIN HEADER
2	80351003	C1, C2	CAP., 35V, 1000 MF, ELECT.
2	884011	Q1, Q2	TRANSISTOR,NPN, 2N6038

8.7 INNER WALL ELECTRONIC CIRCUITRY

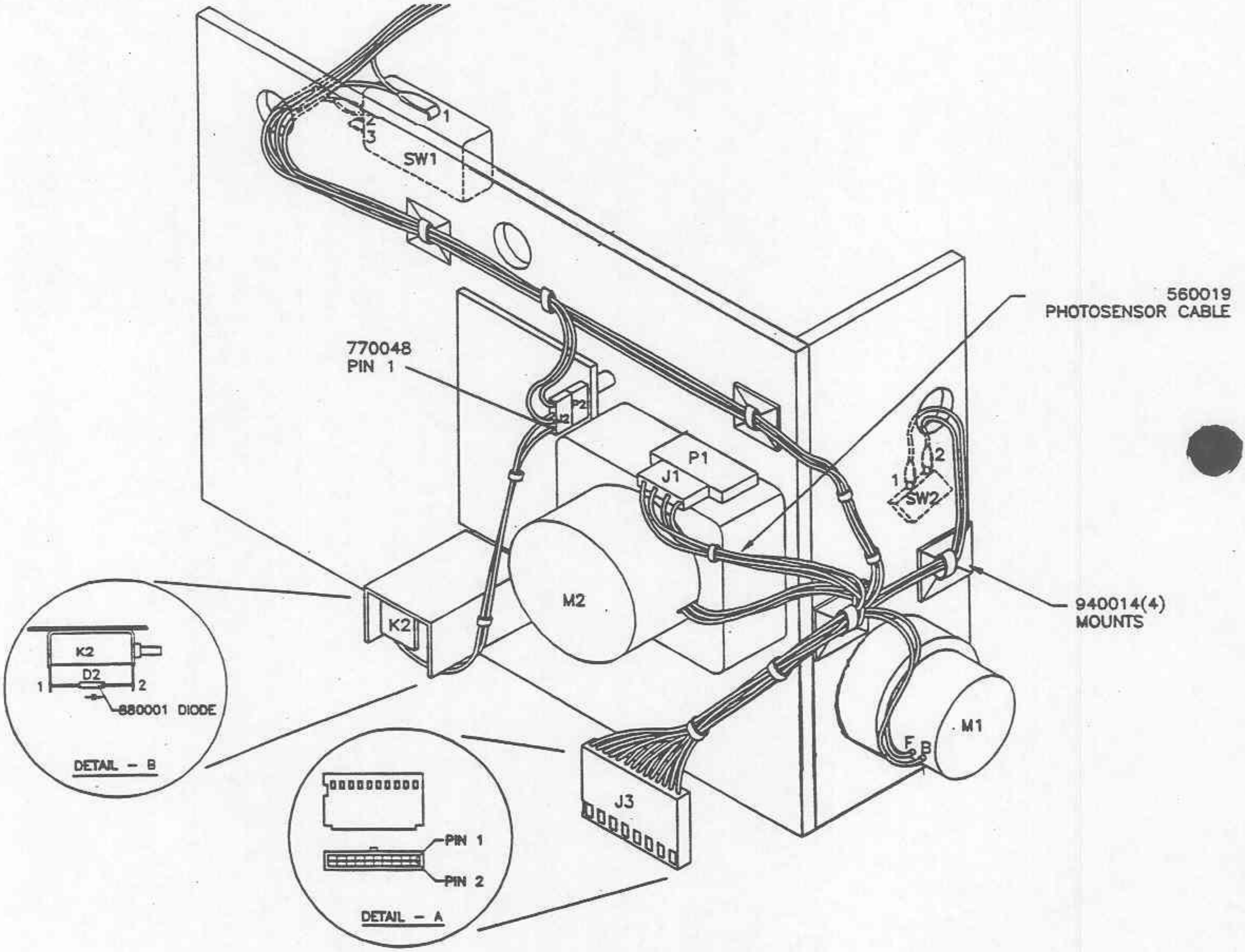

1
2
3
SW1
770048
PIN 1
P2
J2
P1
J1
560019
PHOTOSENSOR CABLE
2
1
SW2
M2
K2
940014(4)
MOUNTS
M1
F
B
J3
K2
D2
1
2
880001 DIODE
DETAIL – B
PIN 1
PIN 2
DETAIL – A

Fig. 8-14, Inner Wall Wiring Diagram

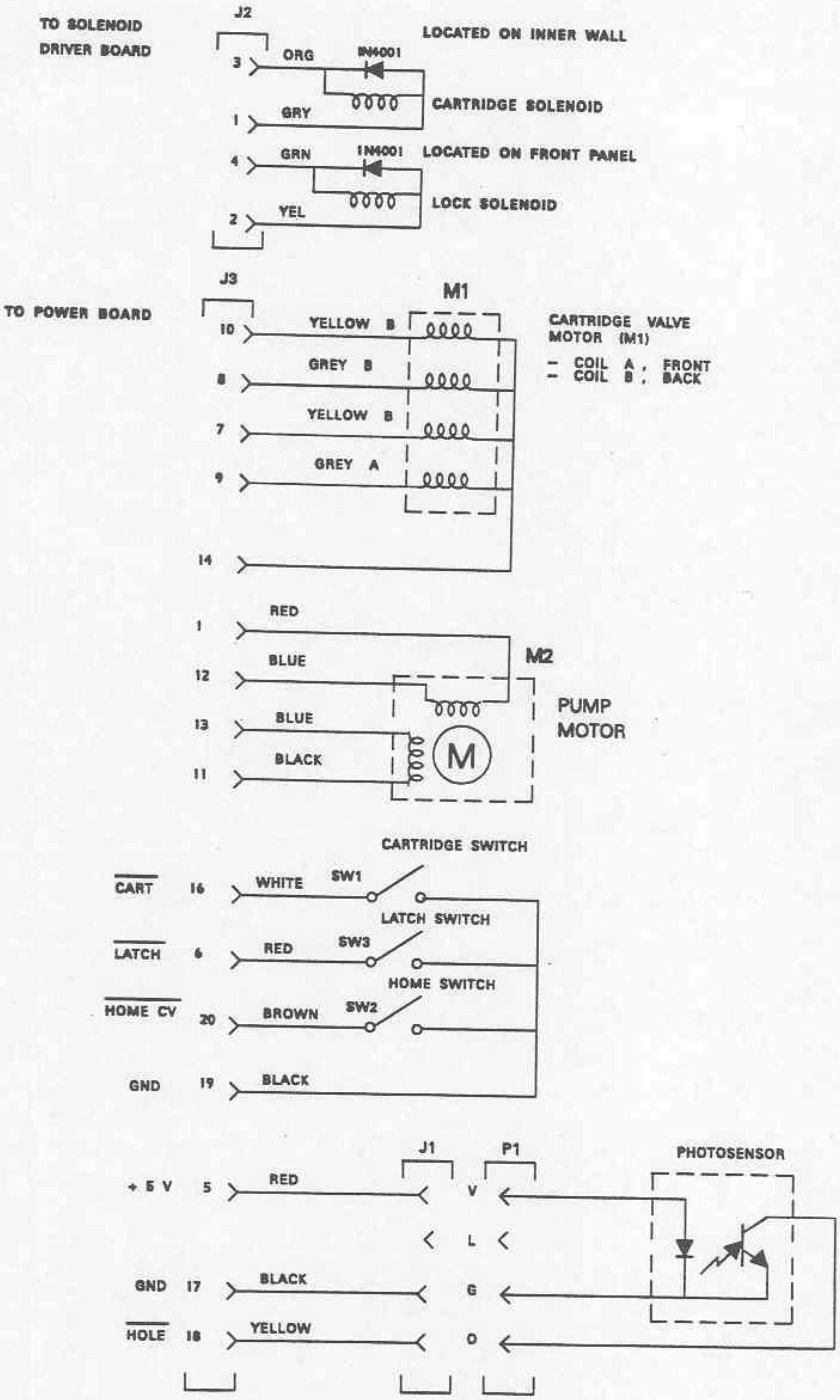

TO SOLENOID DRIVER BOARD
J2
3
ORG
IN4001
LOCATED ON INNER WALL
CARTRIDGE SOLENOID
1
GRY
4
GRN
IN4001
LOCATED ON FRONT PANEL
LOCK SOLENOID
2
YEL
J3
TO POWER BOARD
M1
10
YELLOW B
8
GREY B
7
YELLOW B
9
GREY A
CARTRIDGE VALVE MOTOR (M1)
- COIL A , FRONT
- COIL B ; BACK
14
1
RED
12
BLUE
M2
13
BLUE
11
BLACK
M
PUMP MOTOR
CARTRIDGE SWITCH
CART
16
WHITE
SW1
LATCH SWITCH
LATCH
6
RED
SW3
HOME SWITCH
HOME CV
20
BROWN
SW2
GND
19
BLACK
J1
P1
PHOTOSENSOR
+ 5 V
5
RED
V
L
GND
17
BLACK
G
HOLE
18
YELLOW
O

Fig 8-15, Inner Wall Schematic

8.8 REAR PANEL ELECTRICAL CIRCUITRY

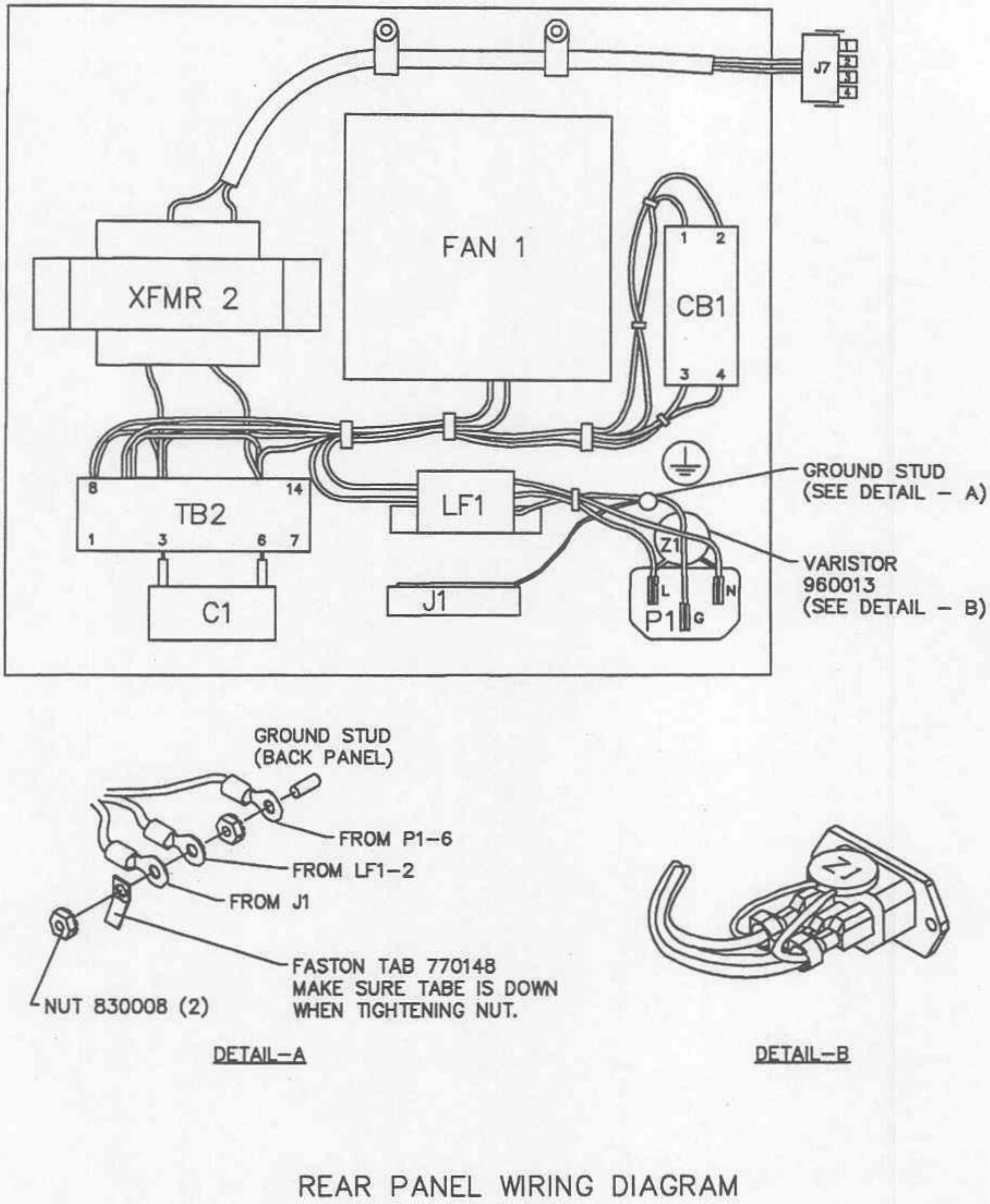
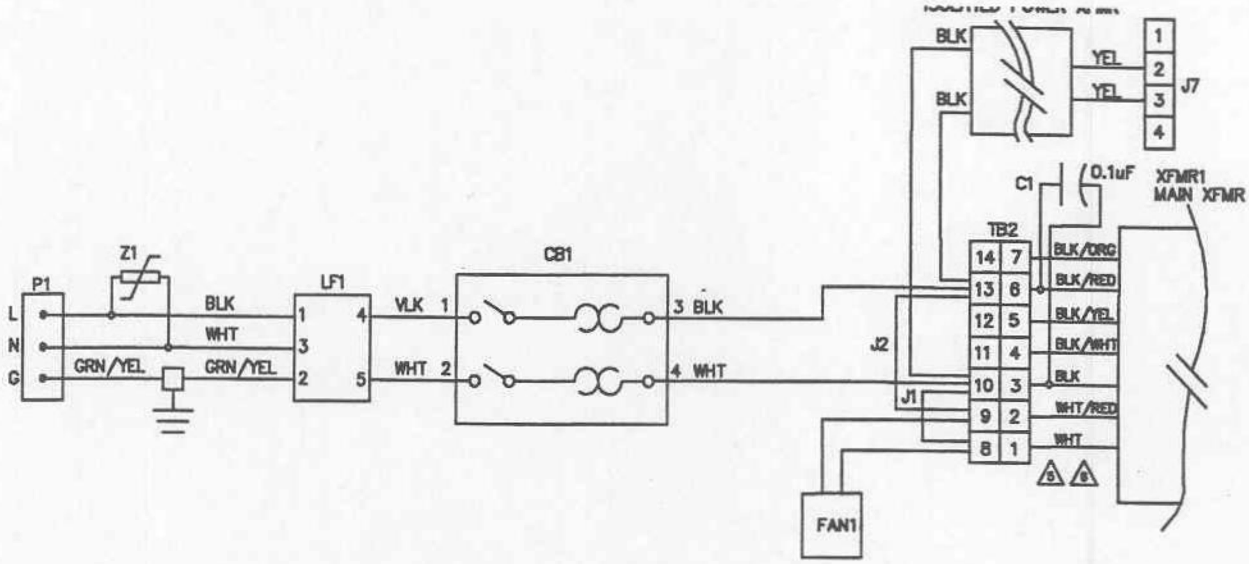

J7
1
2
3
4
FAN 1
XFMR 2
CB1
1 2
3 4
TB2
8
14
1
3
6
7
C1
LF1
J1
Z1
L
N
G
P1
GROUND STUD
(SEE DETAIL – A)
VARISTOR
960013
(SEE DETAIL – B)
GROUND STUD
(BACK PANEL)
FROM P1-6
FROM LF1-2
FROM J1
FASTON TAB 770148
MAKE SURE TABE IS DOWN
WHEN TIGHTENING NUT.
NUT 830008 (2)
DETAIL-A
Z1
DETAIL-B
REAR PANEL WIRING DIAGRAM

Fig. 8-16, Rear Panel Wiring Diagram


BLK
BLK
YEL
YEL
1
2
3
4
J7
C1
0.1uF
XFMR1
MAIN XFMR
TB2
14 7
13 6
12 5
11 4
10 3
9 2
8 1
BLK/ORG
BLK/RED
BLK/YEL
BLK/WHT
BLK
WHT/RED
WHT
△5 △6
Z1
P1
L
N
G
BLK
WHT
GRN/YEL
GRN/YEL
LF1
1
3
2
4
5
VLK 1
WHT 2
CB1
3 BLK
4 WHT
J2
J1
FAN1

WIRE LIST

	ITEM	FROM	TERM	STRIP	AWG	COLOR	LNG	STRIP	TERM	TO
	1	P1–L	△9	1/4	18	BLK	2 3/4	1/4	△2	LF–1
	2			SEE DETAIL – F						S1
	3	P1–N	△9	SEE DETAIL – F						
	4			1/4	18	WHT	3 1/2	1/4	△2	LF–3
	5	P1–G	△2	1/4	18	GRN/YEL	3	1/4	△3	GNDSTUD △8
	6	LF1–2	△2	1/4	18	GRN/YEL	3	1/4	△3	
	7	LF1–4	△2	1/4	18	BLK	10	1/4	△2	CB1–1
	8	LF1–5	△2	1/4	18	WHT	9 1/4	1/4	△2	CB1–2
	9	CB1–3	△2	1/4	18	BLK	8 1/2	1/4	TIN	TB2–13
	10	CB1–4	△2	1/4	18	WHT	10	1/4	TIN	TB2–10
	11	XFMR–2	—	—	—	BLK	2	1/4	TIN	
J1	12	TB2–8	TIN	1/4	18	WHT	2	1/4	TIN	
	13		TIN	1/4	—	—	7 1/2	—	—	FAN
	14	TB2–9	TIN	1/4	—	—	7 1/2	—	—	
J2	15		TIN	1/4	18	BLK	2 3/4	1/4	TIN	TB2–13
	16	XFMR2	—	—	—	BLK	2	1/4	TIN	
	17		—	—	—	YEL	11	1/4	△7	J7–2
	18		—	—	—	YEL	11	1/4	△7	J7–3
	18	C1	SEE DETAIL – C							TB2–3
	20		SEE DETAIL – C							TB2–6
	21	J1	GRD WIRE WITH RINGE TERMINAL							GRDSTUD △8

REAR PANEL SCHEMATIC

Fig 8-17, Rear Panel Schematic

CHAPTER 9; CLEANING PROCEDURES

9.1 BLOOD CLEANING PROCEDURES

During normal conditions, the GEM Stat instrument is not exposed to blood because all blood is contained in the GEM Statpak. However, the possibility of blood contamination is always possible.

Warning

GEM Statpak cartridges containing patient blood samples may carry disease. These cartridges should be disposed of immediately after use by observing standard procedures for bio-hazards. The handler should wear gloves and wash thoroughly after handling the cartridge. Blood spills on or in the instrument present a similar hazard.

If any signs of dirt or blood are noticed while operating or servicing the instrument it should be cleaned immediately.

Materials required for Blood Cleaning

- Disposable rubber or latex gloves
- Chlorine bleach
- Biohazard waste bags
- Lab Coat
- Disposable cleaning rags
- Q-Tip (or similar item)

Warning

Designate a secure quarantine area to store contaminated instruments prior to cleaning where the risk of handling by unknowing persons is eliminated.

Method for cleaning up Blood

- Remove power plug from wall outlet.
- Wear rubber gloves and lab coat.
- Place instrument on non-porous surface.
- Prepare a solution of 50% bleach and 50% water.

- Remove GEM Stat cover, (refer to figure 7-1).
- Immerse cleaning rags in prepared solution. Clean cover inside and out, front keypad and display panel and rear panel being careful around the power switch and fan.
- Inspect bottom chassis "gutters" for blood contamination. Wipe out gutter and use Q-Tip to clean gutter drain hole as required.
- Inspect heater block. Clean any blood from cartridge electrical connector.
- Inspect valve control arm. Clean any blood from it.
- Clean any other bloodied or contaminated areas as required.
- Reassemble GEM Stat and clean power cord and plug from end to end.
- Dispose of all cleaning materials in bio-disposable bag.

9.2 CLEANING FAN FILTER

Note:
Refer to figure 7-9, for fan filter location.

- Unplug power cord.
- Remove the plastic fan filter cover. Be careful not to break the plastic tabs on the top and bottom that hold the cover on.
- Remove filter media and wash in a mild detergent.
- Allow media to dry completely before reinstalling.
- Align filter cover tabs with the notches on the top and bottom of the filter holder.
- Snap cover in place.

APPENDIX 1; DISPLAY MESSAGES

Note:
Refer to Chapter Section 5.6 for a detailed description of Error messages

Display Message:	Description:
BAD DATE	Invalid date was entered. (80<Year<99). Refer to Section 3.5.
BAD LOT NUM!	Invalid lot number for QC solution was entered. (Refer to lot number on GEM Check or GEM Crit Check ampule. Try again.
BAD TIME	Invalid time was entered. Refer to Section 3.5.
CANCELING	Current function is aborting.
CRC FAILED	Hardware error. Refer to Section 5.6.
DATE/TIME?	Accessed through MENU keypad WHEN CARTRIDGE IS NOT INSERTED. Press ENTER to view or set date and/or time, or CANCEL to return to current operation.
EXITING STBY	System is exiting the standby mode. The SHIFT, then 1/STBY keypad was pressed while system was in STANDBY, or the standby time is "used up".
GOING 2 STBY	System is entering the STANDBY mode. The SHIFT then 1/STBY keypad was pressed.
INSERT CART	Instrument is ready to accept cartridge.
LN 000000000	A prompt asking that the QC lot number be entered. Message appears after pressing SHIFT, then the QC keypad.
MUST DO QC	QC has not been run on cartridge. At least "1" QC check must be run prior to analyzing the first blood sample on a new cartridge if the Mandatory QC function is enabled, (refer to Hidden Functions, Section 2.10).
NO GOOD DATA	Data is unavailable to complete the calculation or function that you have just requested.
OP 000000000	Operator ID number. "0's" appear if an operator ID number has not yet been entered, otherwise 0's will be replaced by previously entered operator ID.Refer to Section 5.7.

Display Message:	**Description:**
PA 000000000	Patient ID number. "0's" appear if an patient ID number has not yet been entered, otherwise 0's will be replaced by previously entered patient ID.Refer to Section 5.7.
PLEASE WAIT	A request has been made that cannot be initiated because the instrument is "busy" performing another task.
PRINT ALL QC	Instrument is duplicating all QC printouts at your request.
PRINT ALL?	System is asking if you want to print duplicate all QC and patient sample printouts. Press ENTER to print, CANCEL to abort, or 8/MENU to continue to next request.
PRINT Q-C?	System is asking if you want to print duplicate QC printouts. Press ENTER to print, CANCEL to abort, or 8/MENU to continue to next request.
PROCESS 1:49	Follows SAMPLING; countdown is the time remaining until results are printed and displayed.
QC READY	QC solution is ready to be analyzed, (QC must be aspirated within one minute).
RAM ERROR	Hardware error. Refer to Section 5.6.
R YOU SURE?	A request has been made to remove the cartridge. Press CANCEL to abort or ENTER to unlock door. The same cartridge cannot be reinserted if you press enter.
READY 37.0 C	The instrument is ready to accept samples or other commands. Samples are analyzed at 37.0° C. May later be corrected to patient temperature.
RECOVERING	Instrument is recovering from a power failure. Heater block will take up to (4-1/2) minutes to readjust to correct temperature, followed by a rinse.
REMOVE CART	Cartridge is "used up" (the 24 hour use life or the 50 sample capacity has been reached), or, power was disconnected for more than 30 minutes. You will not be able to analyze more samples on this cartridge.
REMOVE CART?	Appears after the request is made to remove the cartridge. If ENTER key is pressed, "R YOU SURE?" appears. If CANCEL key is pressed system returns to previous mode.
REMOVE SAMPLE	CANCEL key was pressed during "SAMPLING".

Display Message:	Description:
RINSE M:SS	System automatically rinses sensors after PROCESSING, STANDBY, RECOVERING, and Printouts. Countdown shows rinse time remaining.
SAMP CANCEL	CANCEL key was pressed during "PROCESSING."
SAMPLE ERROR	Indicates that sample just processed was aspirated with air. Refer to Section 5.7
SAMPLING	System is aspirating a sample. Takes about 10 seconds.
SELF TEST	Instrument power was just switched ON; lasts for about 10 seconds.
STANDBY	Instrument is in the STANDBY mode. No sampling can take place.
T=XX.X C	Asking for a temperature input so you can temperature correct a sample.
VALVE FAILED	Hardware error. Refer to Section 5.6.
WARMUP 43:00	A new cartridge is hydrating and performing internal calibrations. Countdown indicates time to complete warmup.
3/22/92 - U.S. *22/3/92* - INTL.	Date to which instrument is set; appears after the SHIFT and 8/MENU keypads Date is set during INSERT CART mode. Date must be set correctly to document correct date on printouts.
14:22:33	Time to which instrument is set; always appears in military, or 24-hour format. Time is set during INSERT CART mode. Time must be set correctly to document correct time on printouts.

APPENDIX 2; FORMATS OF TRANSMISSION REPORTS

REPORT TRANSMISSION DESCRIPTION

In addition to normal printouts, reports can be transmitted via the RS232 serial port to a remote computer, printer,or other communication equipment. Refer to Appendix 3 for specifications.

Each line of a transmitted record consists of 20 characters, and is followed by a CR/LF combination. Leading zeroes are suppressed. All data is transmitted in the same format and order as it is printed. The "top" of the printed record is the last line printed, therefore, the information is printed in reverse order (the last line transmitted is the "top" line). The first line of a transmitted report will consist of a record type identifier as:

Calibration report	C,nn
Slope, drift, and bag value report	D,nn
Sample Value report	F,nn
Raw Value report. Refer to Section 6.2	R,nn
Status report	S,nn

app 1

The "ii" is a numerical value used for diagnostic purposes, and should be disregarded by the remote system. A normal sample report will be transmitted as:

Record Header	F,ii
O2 Saturation to nearest tenth	SAT xx.x%
Base Excess to nearest tenth	BE xx.x mmol/L
	TCO2 xx.x mmol/L
Bicarb. to nearest tenth	HCO3 xx.x mmol/L
	CALCULATED RESULTS
Row of 20 "-" (Ascii 93)	--------------------
Calcium to nearest tenth	Ca++ x.xx mmol/L
Potassium to nearest tenth	K+ xx.x mmol/L
Sodium to nearest tenth	Na+ xxx.x mmol/L
	ELECTROLYTES
Hematocrit to nearest unit	Hct xx%
Oxygen to nearest unit	PO2 xxx mmHg
Carbon Dioxide to nearest unit	PCO2 xxx mmHg
pH to nearest hundreth	pH xx.xx
	MEASURED AT 37oC
	BLOOD GASES
Row of 20 "-" (Ascii 93)	--------------------
Operator ID no., up to 9 digits, 0 if none entered	OPER. ID: xxxxxxxxx
Patient ID no., up to 9 digits, 0 if none entered	PAT. ID.: xxxxxxxxx
Date: month/day/year	DATE: mm/dd/yy
Time: Hour'minute	TIME: hh:mm AM (or PM)
Sequential sample number	SAMPLE NUMBER

app 2

Note:
For a sample report, the left column of variables will contain "?" and the parameter value left blank if the last calibration for the parameter failed or the value is beyond a preset limit.

OPERATING MODE SELECTIONS

Several operating mode selections affect the format and content of the printed and transmitted records. It is not practical to present a sample record for every combination of these modes. Therefore, rules for how each mode selection affects the record and several example records are described.

Usage and function of these operating mode selections are described in Section 2.10, Hidden Functions. The effect on the printed and transmitted record follows:

Gases only, Electrolytes only, or Both Modes

If GASES ONLY is selected, pH, PO_2, PCO_2, Hematocrit, and the "calculated parameters" (Sat, BE, TCO_2, and HCO_3) are reported. If ELECTROLYTES ONLY is selected, Na^+, K^+, iCa^{++}, and Hct are reported. If BOTH are selected, all parameters are reported.

Sample Labeling

When this is selected, an extra line is inserted in the report identifying the sample as either ARTERIAL or VENOUS.

Temperature Correction

When a blood sample is temperature corrected (by the user), a block of data is inserted in the report that contains the temperature-corrected gas values.

Calibration Data Reporting

When selected, a report is printed and transmitted at the end of each two-point calibration, and at the half-hour point between hourly two-point calibrations. Previous calibration data records can be printed and are labeled with the word "REPRINT".

EXAMPLES OF REPORT TRANSMISSIONS

Sample Report (Electrolytes only)

```
F,nn
Hct xx %
Ca++ x.xx mmol/L
K+ xx.x mmol/L
Na+ xxx.x mmol/L
ELECTROLYTES
------------------------
OPER. ID: xxxxxxxxx
PAT. ID.: xxxxxxxxx
DATE: mm/dd/yy
TIME: hh:mm AM (or PM)
SAMPLE NUMBER
```

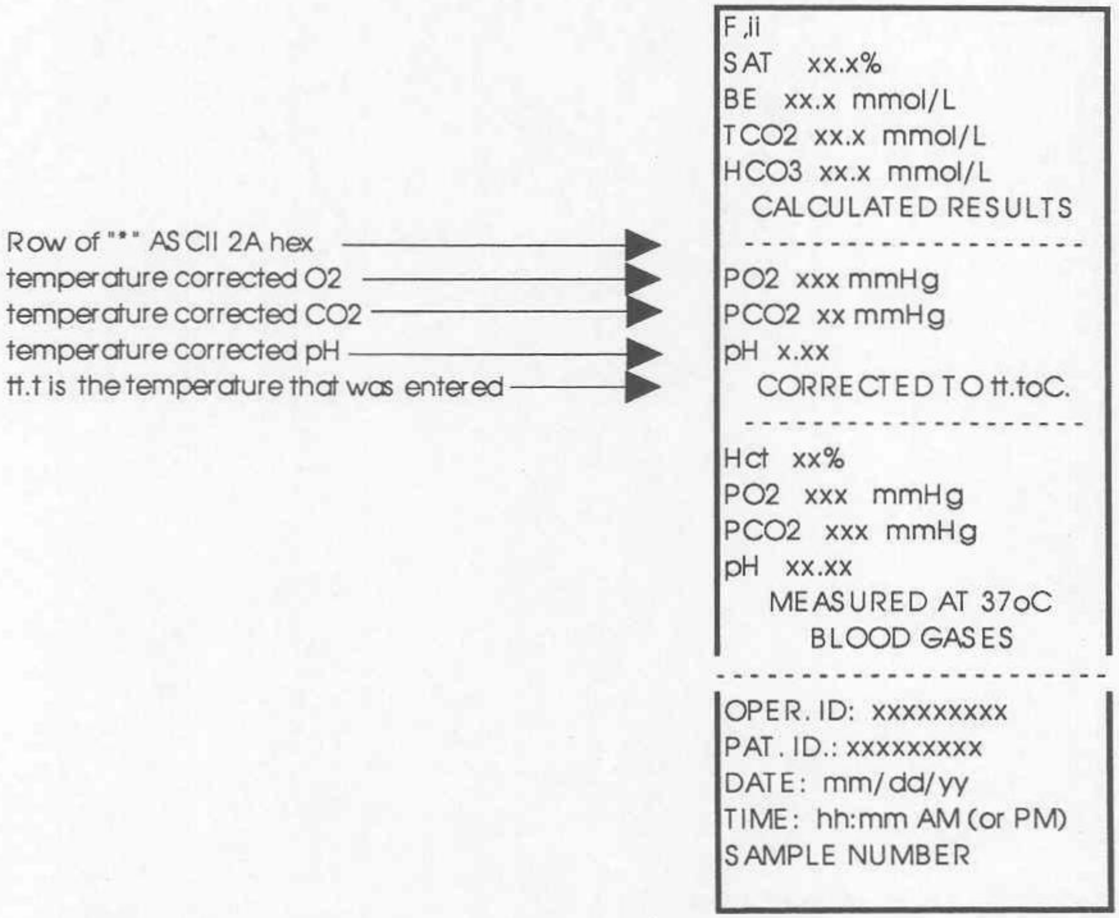
Sample Report (Gases only)

```
F,nn
SAT  xx.x%
BE  xx.x mmol/L
TCO2 xx.x mmol/L
HCO3 xx.x mmol/L
CALCULATED RESULTS
--------------------
Hct xx%
PO2  xxx  mmHg
PCO2  xxx mmHg
pH  xx.xx

MEASURED AT 37oC
BLOOD GASES
-----------------------
OPER. ID: xxxxxxxxx
PAT. ID.: xxxxxxxxx
DATE: mm/dd/yy
TIME: hh:mm AM (or PM)
SAMPLE NUMBER
```

app 3

Sample Report (Temperature Corrected)

If a temperature is entered during the PROCESS interval, an extra block of data, delineated by "-" rows, is added containing the temperature-corrected sample values. Only pH, PO_2, and PCO_2 are affected:


Row of "*" ASCII 2A hex
temperature corrected O2
temperature corrected CO2
temperature corrected pH
tt.t is the temperature that was entered

```
F,ii
SAT    xx.x%
BE  xx.x mmol/L
TCO2 xx.x mmol/L
HCO3 xx.x mmol/L
  CALCULATED RESULTS
 --------------------
PO2 xxx mmHg
PCO2 xx mmHg
pH x.xx
  CORRECTED TO tt.toC.
 --------------------
Hct  xx%
PO2  xxx  mmHg
PCO2  xxx mmHg
pH  xx.xx
    MEASURED AT 37oC
      BLOOD GASES
-----------------------
OPER. ID:  xxxxxxxxx
PAT. ID.: xxxxxxxxx
DATE:  mm/dd/yy
TIME:  hh:mm AM (or PM)
SAMPLE NUMBER
```

Sample Report (labeling enabled)

With Sample Labeling enabled, an extra line is added between the Operator and the row labeled "VENOUS" or "ARTERIAL" to identify the type of sample:

```
F,nn
Hct xx %
Ca+ +  x.xx  mmol/L
K+  xx.x  mmol/L
Na+   xxx.x  mmol/L
      ELECTROLYTES
-----------------------
VENOUS SAMPLE

OPER. ID:  xxxxxxxxx
PAT. ID.: xxxxxxxxx
DATE:  mm/dd/yy
TIME:  hh:mm AM (or PM)
SAMPLE NUMBER
```

5

Sample Report (longest)

The longest report is a "gases and Electrolytes" report with temperature correction and sample labeling enabled:

```
F,ii
SAT   xx.x%
BE   xx.x  mmol/L
TCO2  xx.x  mmol/L
HCO3  xx.x  mmol/L
  CALCULATED RESULTS
  --------------------
Ca+ +  x.xx  mmol/L
K+   xx.x  mmol/L
Na+    xxx.x  mmol/L
      ELECTROLYTES
  --------------------
PO2  xxx mmHg
PCO2  xx mmHg
pH  x.xx
   CORRECTED TO tt.toC.
  --------------------
Hct  xx%
PO2   xxx   mmHg
PCO2   xxx  mmHg
pH   xx.xx
MEASURED AT 37oC
BLOOD GASES
ARTERIAL SAMPLE
OPER. ID:  xxxxxxxxx
PAT. ID.: xxxxxxxxx
DATE:  mm/dd/yy
TIME:  hh:mm AM (or PM)
SAMPLE NUMBER
```

6

QC Report (electrolytes only)

```
F,nn
Ca++  x.xx  mmol/L
K+  xx.x  mmol/L
Na+   xxx.x  mmol/L

LOW LEVEL SAMPLE

LOT NUM:   xxxx

OPER. ID:  xxxxxxxxx
DATE:  mm/dd/yy
TIME:  hh:mm AM (or PM)
QUAL. CONTROL CHECK.
SAMPLE NUMBER xx
```

Identifies "low", "Normal", or "High" level sample → LOW LEVEL SAMPLE

Lot number entered by the operator → LOT NUM
(taken off of the QC ampule)

Identifyes the sample as QC → QUAL. CONTROL CHECK.
(as opposed to a blood sample)

QC Report (gases and electrolytes)

b

```
F,nn
Ca++  x.xx  mmol/L
K+  xx.x  mmol/L
Na+   xxx.x  mmol/L
PO2  xxx  mmHg
PCO2  xxx  mmHg
pH  xx.xx
LOW LEVEL SAMPLE

LOT NUM:   xxxx

OPER. ID:  xxxxxxxxx
DATE:  mm/dd/yy
TIME:  hh:mm AM (or PM)
QUAL. CONTROL CHECK.
SAMPLE NUMBER xx
```

1-Point CAL Report (Electrolytes Only)

a

"d" identifies this print-out as a "drift" or 1-Point Cal report.

```
d,NN
--------------------
Hct  -.xx   xx.x %
PO2  .xx  xxx. mmHg
PCO2  .xx  xx.x mmHg
pH   .xxx  x.xx
DRIFT B  CAL B
DATE:  mm/dd/yy
TIME:  hh:mm AM (or PM)
1-POINT  CAL VALUES
```

2-Point CAL Report (Gases and Electrolytes with CAL-STAT enabled)

10

```
D,ii
--------------------
Hct .xx  xx %
Ca++  .xx  x.xx  mM
Na+  xx.x  xxx.x  mM
K+  x.xx  x.xx  mM
PO2  .xx  xxxx  mmHg
PCO2  .xx  xxx.  mmHg
pH  .xxx  x.xx
          DRIFT B CAL B
Ca++  .xx . xx  mM
Na+  -x.xx  xxx.x  mM
K+  .xx  x.xx  mM
PO2  ..xx  xx.x  mmHg
PCO2  .xx  xx.x  mmHg
pH  .x.xxx  x.xx
          DRIFT A CAL A
     2-POINT CAL VALUES
Hct  x.x  mV/mho
Ca++  x.xx  mV/dec
K+  xx.x  mV/dec
Na+   xxx.x  mV/dec
PO2  xx.x  pA/mmHg
PCO2  xx.x  mV/dec
pH  xx.x  mV/dec
     ELECTRODE SLOPES
DATE:  mm/dd/yy
TIME:  hh:mm AM (or PM)
--------------------
```

LAST CAL (reprints last 2-Point CAL Report, electrolytes only)

11

"* REPRINT * " identifies the report as a reprint of a prior calibration.

```
D,ii
--------------------
Hct .xx  xx %
Ca++  .xx  x.xx  mM
Na+  xx.x  xxx.x  mM
K+  x.xx  x.xx  mM
          DRIFT A CAL A
     2-POINT CAL VALUES
Hct  x.x  mV/mho
Ca++  x.xx  mV/dec
K+  xx.x  mV/dec
Na+   xxx.x  mV/dec
     ELECTRODE SLOPES
DATE:  mm/dd/yy
CAL TIME:  hh:mm AM (or PM)
          * REPRINT *
--------------------
```

12

Sample Report (after several electrodes had CAL failures)

```
F,ii
SAT  100.0%
?BE  -9.2 mmol/L
?TCO2 16.2 mmol/L
?HCO3 14.6 mmol/L
   CALCULATED RESULTS
 --------------------
?Ca++  .54 mmol/L
K+  2.9 mmol/L
?Na+  136.2 mmol/L
        ELECTROLYTES
?Hct  10%
?PO2 0 mmHg
?PCO2 51 mmHg
?pH 7.07

     MEASURED AT 37oC
       BLOOD GASES
----------------------
VENOUS SAMPLE
OPER. ID: 3258746
PAT. ID.: 7845699
DATE: 04/30/92
TIME: 3:05 PM
SAMPLE NUMBER 02
```

13

Sample Report (Flawed sample test)
Indicates air was aspirated with sample. Causes may be: pumping error, sample removed too soon, large air bubble in sample.

```
ERROR
DUE TO SAMPLING
SAMPLE CANCELLED
OPER. ID: 3258746
DATE: mm/dd/yy
TIME: hh:mm AM or PM
SAMPLE NUMBER xx
```

Raw Count Value Report

Raw counts are unprocessed digital values for the electrodes and other signal sources. They are printed only when the raw count option in the "hidden menu" is turned ON. See section x, Operation Overview.

Record Header	R,nn	COUNTS nnnn
"B" before sample	DB2	COUNTS nnnn
No longer used	DB1	COUNTS nnnn
Counts for TEST input of analog MUX	TEST	COUNTS nnnn
Venous Thermistor Input	VN_TMP	COUNTS nnnn
Arterial Thermistor Input	AR_TMP	COUNTS nnnn
No longer used	SPARE	COUNTS nnnn
Heater Block Thermistor counts	HEATER	COUNTS nnnn
O2 channel	O2	COUNTS nnnn
REF channel	REF	COUNTS nnnn
pH channel	pH	COUNTS nnnn
K+ channel	K+	COUNTS nnnn
Ca+ + channel	Ca+ +	COUNTS nnnn
Na+ channel (not a mistake)	CO2REF	COUNTS nnnn
CO2 channel	CO2-CREF	COUNTS nnnn
Hematocrit channel	HCT	COUNTS nnnn
No longer used	PRESS	COUNTS nnnn
Reference voltage	ref 2.5	COUNTS nnnn
Ground	GROUND	COUNTS nnnn

Date	DATE: mm/dd/yy	
Type of solution (A or B)	SOLUTION TYPE B	
Not a real time, a running counter	TIME: hh:mm AM (or PM)	

Report after Power Failure

If the power fails, or is switched off and restored with a cartridge in place, the following message is transmitted (and printed):

Time of power restoration	TIME: hh:mm PM
	POWER RESTORED AT
Time of power failure	TIME: hh:mm
	POWER FAILED AT

16

Status report (all electrodes operational)

Record Identifier	S,nn
Time remaining until next 2-point calibration	NEXT CAL IN: h:mm:ss
Total number of QC samples run on cartridge	QC SAMPLES: xx
Total number of blood samples run on cartridge	BLOOD SAMPLES: xx
Total standby time remaining on current cartridge	STANDBY TIME: hh:mm
Total active time remaining on current cartridge	RUN TIME: hh:mm
	CARTRIDGE LIFE USED:
Total standby time used on current cartridge	STANDBY TIME: hh:mm
Total samples used on current cartridge	SAMPLES: xx
Total active time remaining on current cartridge	TIME: hh:mm
	CARTRIDGE LIFE REMAINING:
Current operating mode (either RUN or STANDBY)	CURRENT MODE: RUN
Date of status report	DATE: mm/dd/yy
Time of status report	TIME: hh:mm: PM
Report header	STATUS REPORT

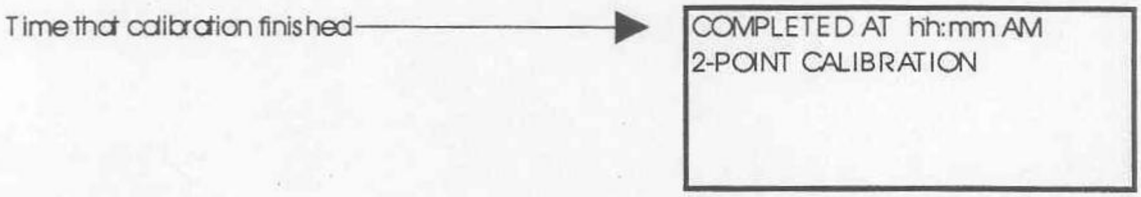
17

Status Report (after several calibration failures)

Record Identifier	S,nn
Electrode failure message	K+
Electrode failure message	Hct
Electrode failure message	pH
Time remaining until next 2-point calibration	NEXT CAL IN: h:mm:ss
Total number of QC samples run on cartridge	QC SAMPLES: xx
Total number of blood samples run on cartridge	BLOOD SAMPLES: xx
Total standby time remaining on current cartridge	STANDBY TIME: hh:mm
Total active time remaining on current cartridge	RUN TIME: hh:mm
	CARTRIDGE LIFE USED:
Total standby time used on current cartridge	STANDBY TIME: hh:mm
Total samples used on current cartridge	SAMPLES: xx
Total active time remaining on current cartridge	TIME: hh:mm
	CARTRIDGE LIFE REMAINING:
Current operating mode (either RUN or STANDBY)	CURRENT MODE: RUN
Date of status report	DATE: mm/dd/y
Time of status report	TIME: hh:mm: P
Report header	STATUS REPORT

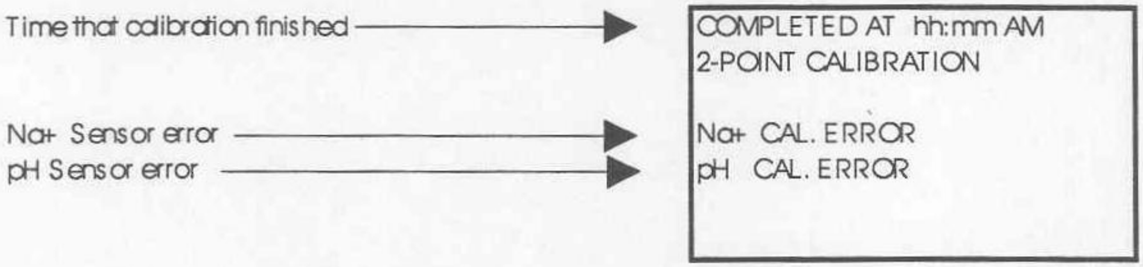
2-Point CAL Completion Message (no electrode failures, CAL-STAT disabled)

This message prints following the completion of every 2-point calibration.


Time that calibration finished

```
COMPLETED AT  hh:mm AM
2-POINT CALIBRATION
```

2-Point CAL Completion Message (electrode slope errors detected)


Time that calibration finished
Na+ Sensor error
pH Sensor error

```
COMPLETED AT  hh:mm AM
2-POINT CALIBRATION

Na+  CAL. ERROR
pH   CAL. ERROR
```

APPENDIX 3; RS-232 COMMUNICATIONS SPECIFICATION

GENERAL DESCRIPTION

The GEM Stat Instrument has a serial communications port which allows data transmission to a remote computer, terminal, printer, or other data communication equipment. The port is configured as a standard RS-232 port, and all data is transmitted as ASCII characters.

Data is transmitted in the same format as it is printed. Since the GEM Stat printer operates in a data logging configuration, the last line in a transmitted record is the first line printed. Hence, any remote device which displays or prints the data in the exact format as it is transmitted will show a record in reverse order (refer to Appendix 2.).

CONNECTOR AND SIGNAL DESCRIPTION

The RS-232 port connector is a standard "DB-25" female connector. The pinout follows the RS-232 standard for data communication equipment, and is as follows:

PIN	SIGNAL	NOTES
1	Protective Ground	Connected to GEM Stat Line Ground
2	TxD	Data TO remote device.
3	RxD	Data FROM remote device.
4	RTS	Request To Send (always high).
5	CTS	Clear To Send (From remote; MUST be pulled high in order for the GEM to transmit)*
6	DSR	Data Set Ready (From remote, not used.
7	GND	Signal Ground
20	DTR	Data Terminal Ready (always high).

BAUD RATE, FORMAT, AND HANDSHAKING

Baud rate is fixed at 9600. The format is one start bit, 8 data bits, no parity and one stop bit. Software handshaking (X-ON, X-OFF) is implemented, as well as hardware handshaking, using CTS.*

*The GEM Stat Instrument does not require hardware handshaking. A simple 3-wire interface can be used. Connect pins 7 of both ends together, connect Pin 2 of the GEM Stat to the data input of the remote device, and Pin 3 of the GEM Stat to the data output of the remote device. Shielded cable should be used if the two devices are more than 10 feet apart. The shield of the cable should be connected to Pin 1 at one end only.

DATA TRANSMISSION PROTOCOL

When a record of any type (Sample data, Status report, Error printout) is being printed, the same data is written into a communications buffer for transmission. If transmission is enabled, (no X-OFF received and CTS line positive), the record will be transmitted.

Transmission of the data empties the buffer, hence, once transmitted, the record can not be transmitted again.

X-ON and X-OFF are recognized at any time. If X-OFF is received during data transmission, data transmission will cease after the byte being transmitted. A subsequent X-ON, at any time before another record is printed, will cause transmission to begin again with the next byte (character) in the communication buffer.

An X-OFF received at any time when data is not being transmitted will be recognized and stored. Transmission of data will be inhibited until a subsequent X-ON is received. If X-ON is received during data printout, transmission will begin at the top of the buffer, which will contain the current record being printed.

The Clear-To-Send (CTS) input functions in a similar manner. If the CTS line is low, transmission is inhibited. If the CTS line is pulled low during data transmission, transmission will cease after the byte being transmitted. If the line is subsequently brought high, transmission will begin with the next byte in the record.

At the time of this writing, the communications buffer is limited to 256 characters. A complete sample record is about 400 characters in length. When the last location in the communications buffer has been filled, the buffer will "wrap around", that is, data will then be written to the first and subsequent locations. If these locations have not been transmitted (Due to an active X-OFF or CTS low), these data will be lost. Therefore, it is necessary for the receiving device to take the data essentially as fast as it is transmitted. Since average transmission rate is limited by the thermal printer throughput rate, about 40 characters per second, this should not place any burden on the receiving device.

When a new record is printed, it will also be written into the communications buffer. If the previous record was not transmitted, it will be lost.

APPENDIX 4; ELECTROMECHANICAL SPECIFICATIONS

POWER SUPPLIES

The GEM Stat Instrument contains a power supply assembly which delivers the following regulated supply voltages. Regulation is guaranteed over the line voltage tolerance range.

- +5 VDC +/- 50 mV @ 3 AMP Max.
- +5.5 VDC +/- 0.1V @ 100 mA Max.
- +12 VDC +/- 60 mV @ 400 mA Max
- -12 VDC +/- 60 mV @ 100 mA Max.
- +24 VDC +/- 0.25 V @ 2.5A Max., intermittent duty: 1/3 duty cycle.

In addition, the A/D circuit board contains regulated supplies for the isolated circuitry:

- +15 VDC +/- 0.75V @ 0.18A. Max.
- +15 VDC +/- 0.75V @ 0.18A. Max.

ELECTRODE BUFFER AMPLIFIERS (REF, PH, CA++, NA+, K+ AND CO_2 ELECTRODES)

- Input Impedance: $(10)^{12}$ ohms minimum
- Gain: 1.00 +/- 0.01%

OXYGEN CHANNEL

- Polarization Voltage: -740 mV +/- 20 mV with respect to Common.
- Current/Voltage transformation factor: 25 mV/nanoA+/- 2%.

HEMATOCRIT CHANNEL

- Excitation: 1.2 VRMS +/- 15%, 500 Hz +/- 20% through 200K Ohms +/- 1%
- Input Impedance of amplifier: 1000 Megaohms, minimum
- Detection: Precision peak detector.

DIFFERENTIAL GAIN STAGES, PH, CA++, NA+, K+, CO_2

- Gain: 10.0 +/- 0.2%
- Common Mode Rejection: 54 dB minimum.
- Na, Ca, pH, and K gain stages are offset by + .355V +/- 2% referred to non-inverting input to accommodate REF electrode offset.

HEATER BLOCK THERMOSTATING

- Method: On-Off
- Set-point: 37.0°C +/- 0.2° C
- Thermal Excursions: Less than 0.1°C peak to peak.
- Regulation: Set-point maintained to within +/- 0.5°C over rated ambient temperature range.

ANALOG-TO-DIGITAL CONVERSION

- Method: Voltage to frequency conversion and accumulation.
- Dynamic Range: -2.5V to +2.5V (to +5.0 at reduced linearity).
- Linearity: +/- 0.01% maximum from straight line drawn through origin and full scale.
- Resolution: 1 Count = 167 micro-V (16.7 micro-Volts at electrode inputs) +/- 20%.
- Scale Factor: 6000 counts/Volt-second +/- 10%.

CARTRIDGE VALVE STEPPER MOTOR

- Angular resolution: 0.3 Degrees/Step
- Available torque: 34.4 oz.-in at 100 steps/sec or less.
- "Home" switch actuation point: +/- 2 Degrees.

PUMP MOTOR/ROTOR SYSTEM

- Synchronous AC type, 24 V.
- Rotating Speed: 20 RPM
- Angular resolution: 2.0 Degrees/Cycle
- Available torque: 127 oz-in at 102 VAC Line

MICROPROCESSOR TIME BASE

- Clock cycle time: 1.08507 micro-seconds +/- 0.01%

RS232 PORT

All primary functions are implemented in hardware (TxD, RxD, RTS, DTR, CTS, DRS). Voltage level at output are +/- 12V. Operating conditions (baud rate, handshaking, parity, etc.), are determined by software (refer Appendix 3.)

BATTERY BACKED MEMORY

- Data integrity is guaranteed during brownout or power fail.
- Data retention is 5 years minimum.

REAL TIME CLOCK

The GEM Stat is equipped with a real-time calendar clock to permit the printing of time and date on a sample record. The clock is powered by battery on A/D Board.

PRINTER

- Fixed Head dot array thermal type, 20 columns wide.
- Paper type-Thermal, MSS #2308.
- Speed: 22 characters per second, maximum.

ISOLATION AND LEAKAGE CURRENTS

This applies only to circuitry making electrical contact with the blood sample.

The GEM Statpak cartridge electrodes are in electrical contact with the blood sample. All circuits connected to these electrodes are electrically and physically isolated from other electrical circuits in the GEM Stat Instrument. All such isolated circuits are powered by a separate power transformer designed to both withstand high voltage and produce low leakage. The specifications for this circuitry are:

Dielectric Withstand Voltage

- Between line circuit and any isolated part: 4000 VAC.
- Between any isolated part and ground, chassis, or any non-isolated part not in the line circuit: 1800 VAC.
- Between line circuitry and ground or any non-isolated part: 1800 VAC

Maximum Leakage Currents

During a single-fault condition in which the isolated circuitry is excited with 120 VRMS, 60HZ, as measured between isolated connection and any other part of the GEM Stat System including line circuit: 10 micro-amperes maximum.

During a single-fault condition in which the ground lead of the line cord is opened, as measured between the enclosure or any other part and earth ground (or the ground connection of the line voltage connector: 75 micro-amperes maximum.

Physical Spacing

Between conductive parts in the isolated circuitry and any other conductive part:

- Creepage (over surfaces): .315 inch (8.0 mm) minimum.
- Through air: .20 inch (5.0 mm) minimum.

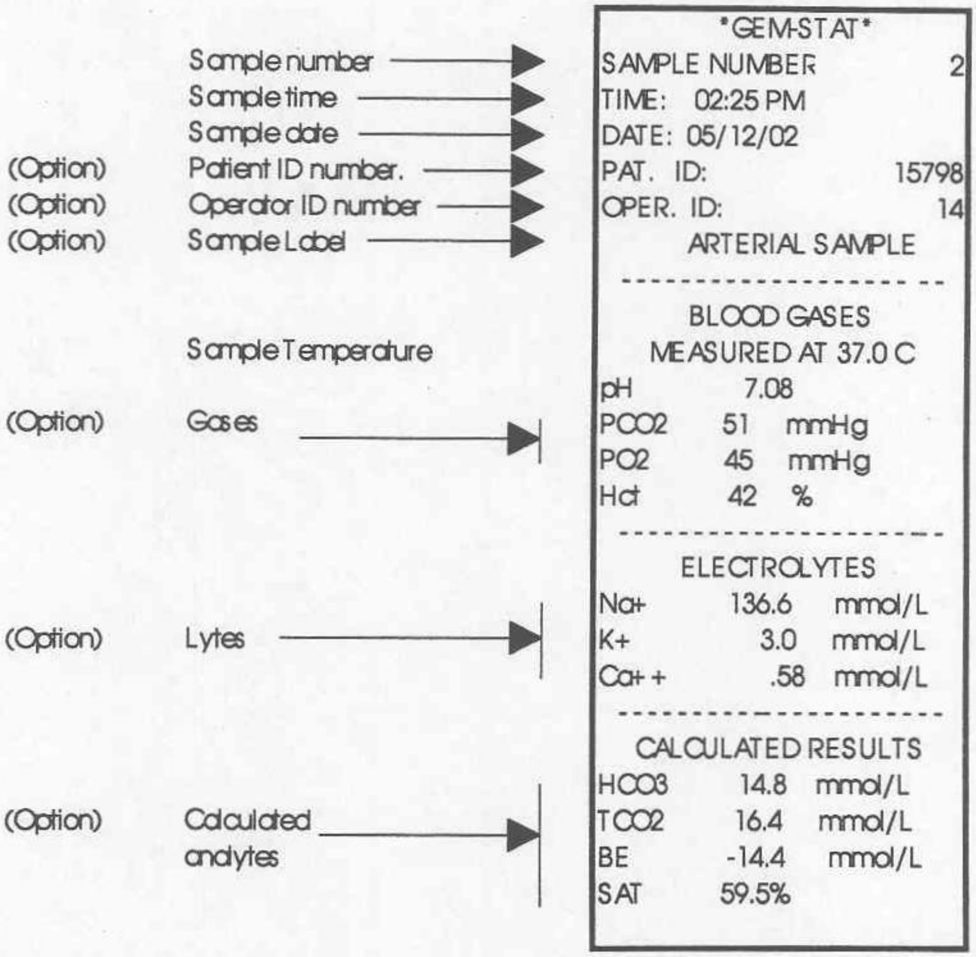
Between parts in the line circuit and any other part (except parts of the isolated circuitry):

- Creepage: 0.118 inch (3.0 mm) minimum.
- Through air: 0.062 inch (1.6 mm) minimum.

APPENDIX 5; PRINTOUTS

GENERAL INFORMATION

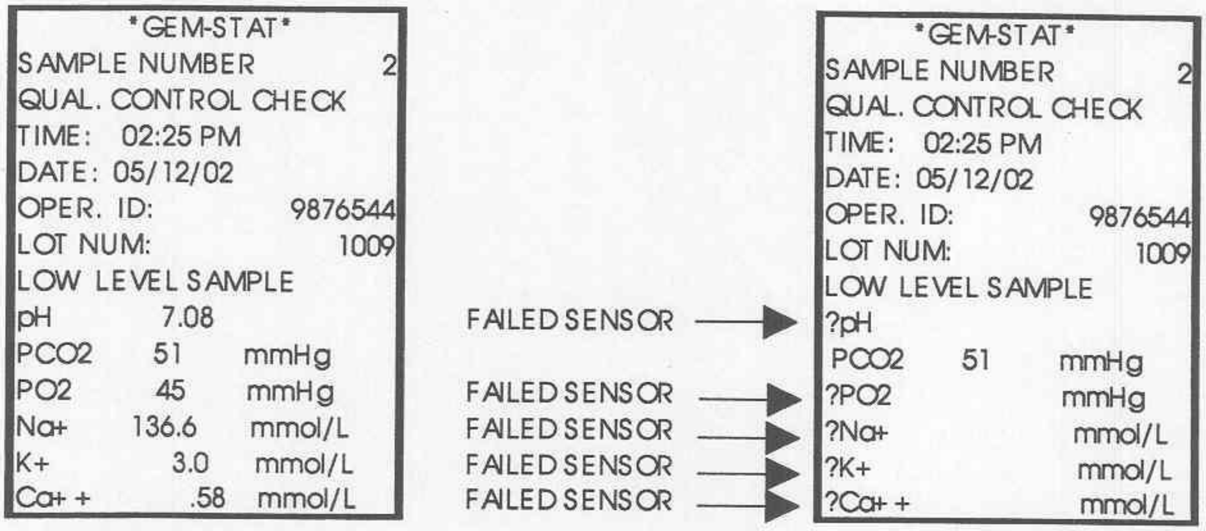
Refer to Section 3.2 for procedures on obtaining a Sample Printout and Section 3.3 for Calibration and QC Printouts.


Sample number
Sample time
Sample date
(Option) Patient ID number.
(Option) Operator ID number
(Option) Sample Label
Sample Temperature
(Option) Gases
(Option) Lytes
(Option) Calculated analytes

```
        *GEM-STAT*
SAMPLE NUMBER              2
TIME:   02:25 PM
DATE: 05/12/02
PAT. ID:               15798
OPER. ID:                 14
      ARTERIAL SAMPLE
 ---------------------- --
       BLOOD GASES
    MEASURED AT 37.0 C
pH          7.08
PCO2     51    mmHg
PO2      45    mmHg
Hct      42    %
 ------------------------
       ELECTROLYTES
Na+        136.6    mmol/L
K+           3.0    mmol/L
Ca++         .58    mmol/L
 ------------------------
    CALCULATED RESULTS
HCO3       14.8   mmol/L
TCO2       16.4   mmol/L
BE         -14.4   mmol/L
SAT      59.5%
```

Fig A5-1, Sample Report, printout. (No Sensor failures)

> Note:
> If the last calibration for the parameter failed or the value is beyond a preset limit, the sample report will contain a "?" in the left column and the parameter value left blank.



```
        *GEM-STAT*
SAMPLE NUMBER              2
QUAL. CONTROL CHECK
TIME:   02:25 PM
DATE: 05/12/02
OPER. ID:            9876544
LOT NUM:                1009
LOW LEVEL SAMPLE
pH         7.08
PCO2       51      mmHg
PO2        45      mmHg
Na+      136.6     mmol/L
K+          3.0    mmol/L
Ca+ +       .58    mmol/L
```

(No sensor failures)

```
        *GEM-STAT*
SAMPLE NUMBER              2
QUAL. CONTROL CHECK
TIME:   02:25 PM
DATE: 05/12/02
OPER. ID:            9876544
LOT NUM:                1009
LOW LEVEL SAMPLE
?pH
 PCO2      51      mmHg
?PO2               mmHg
?Na+               mmol/L
?K+                mmol/L
?Ca+ +             mmol/L
```

FAILED SENSOR
FAILED SENSOR
FAILED SENSOR
FAILED SENSOR
FAILED SENSOR

(Multiple sensor failures)

Fig. A5-2, QC reports

PRINTOUT OPTIONS ACCESSED FROM HIDDEN FUNCTION MENU

Changing printout options affect the format and content of the printed and transmitted records. It is not practical to present a sample record for every combination of these modes. Therefore, rules for how each mode selection affects the record and several example records are described.

Usage and function of these printout options are described in Section 2.10, Customizing the System, "Hidden Functions".

Gases only, electrolytes only, or both modes.

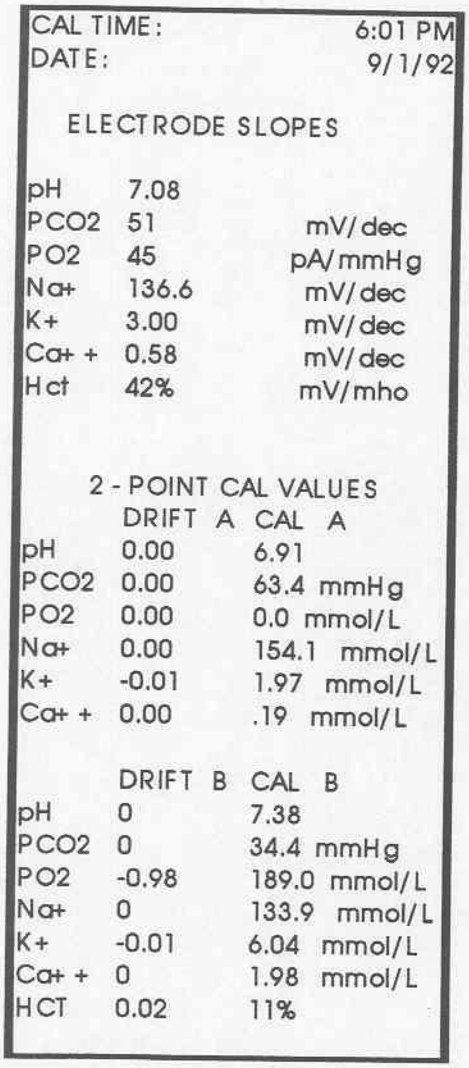
If GASES ONLY is selected, pH, PO_2, PCO_2, Hematocrit, and the "calculated parameters" (SAT, BE, TCO_2, and HCO_3) are reported. If ELECTROLYTES ONLY is selected, Na^+, K^+, iCa^{++}, and Hct are reported. If BOTH are selected, all parameters are reported.

Sample labeling.

When this is selected, an extra line is inserted in the report identifying the sample as either ARTERIAL or VENOUS.

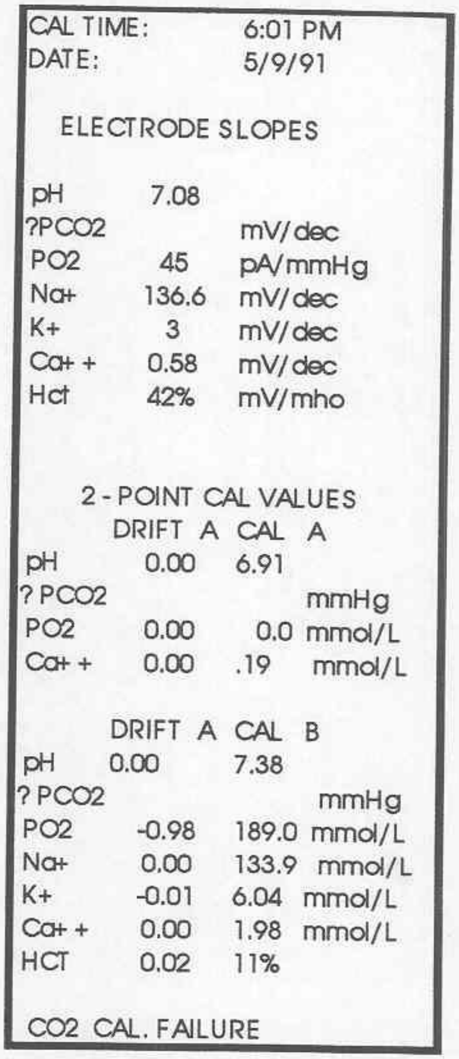
Calibration Data reporting.

When CAL-STAT is ON, a detailed report is printed and transmitted at the end of each two-point calibration listing; Cal-A drift, Cal-B drift and slope for each sensor. In addition, a 1-Point Cal-B report is printed on the half hour between 2-Point Cal reports that reports the latest Cal-B drift for each sensor.



```
CAL TIME:                    6:01 PM
DATE:                         9/1/92

   ELECTRODE SLOPES

pH      7.08
PCO2    51              mV/dec
PO2     45             pA/mmHg
Na+     136.6           mV/dec
K+      3.00            mV/dec
Ca+ +   0.58            mV/dec
Hct     42%             mV/mho


     2 - POINT CAL VALUES
        DRIFT  A   CAL  A
pH      0.00       6.91
PCO2    0.00       63.4 mmHg
PO2     0.00       0.0 mmol/L
Na+     0.00       154.1  mmol/L
K+      -0.01      1.97  mmol/L
Ca+ +   0.00       .19  mmol/L

        DRIFT  B   CAL  B
pH      0          7.38
PCO2    0          34.4 mmHg
PO2     -0.98      189.0  mmol/L
Na+     0          133.9  mmol/L
K+      -0.01      6.04  mmol/L
Ca+ +   0          1.98  mmol/L
HCT     0.02       11%
```

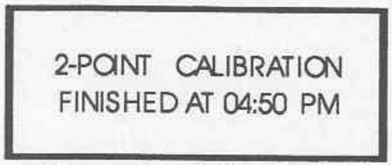
(No sensor failures)



```
CAL TIME:           6:01 PM
DATE:               5/9/91

  ELECTRODE SLOPES

pH        7.08
?PCO2               mV/dec
PO2        45       pA/mmHg
Na+       136.6     mV/dec
K+          3       mV/dec
Ca+ +     0.58      mV/dec
Hct       42%       mV/mho


    2 - POINT CAL VALUES
       DRIFT  A   CAL  A
pH        0.00    6.91
? PCO2                  mmHg
PO2       0.00     0.0 mmol/L
Ca+ +     0.00    .19    mmol/L

       DRIFT  A   CAL  B
pH      0.00      7.38
? PCO2                   mmHg
PO2       -0.98   189.0 mmol/L
Na+       0.00    133.9  mmol/L
K+        -0.01   6.04  mmol/L
Ca+ +     0.00    1.98  mmol/L
HCT       0.02    11%

CO2  CAL. FAILURE
```

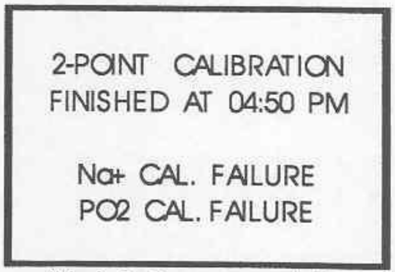
(CO2 sensor failure)

Fig. A5-3, 2-Point CAL Reports (with CAL-STAT ON)



```
2-POINT   CALIBRATION
FINISHED AT 04:50 PM
```

(No sensor failures)



```
2-POINT   CALIBRATION
FINISHED  AT  04:50  PM

 Na+  CAL.  FAILURE
 PO2  CAL.  FAILURE
```

(Na^+ & O_2 sensor failures)

Fig. A5-4, 2-Point CAL Reports (with CAL-STAT OFF).

MISCELLANEOUS FUNCTIONS' AFFECT ON PRINTOUTS

Miscellaneous functions are a group of unrelated functions. Information on Miscellaneous Functions and their usage is described in Section 3.5

DATE and TIME

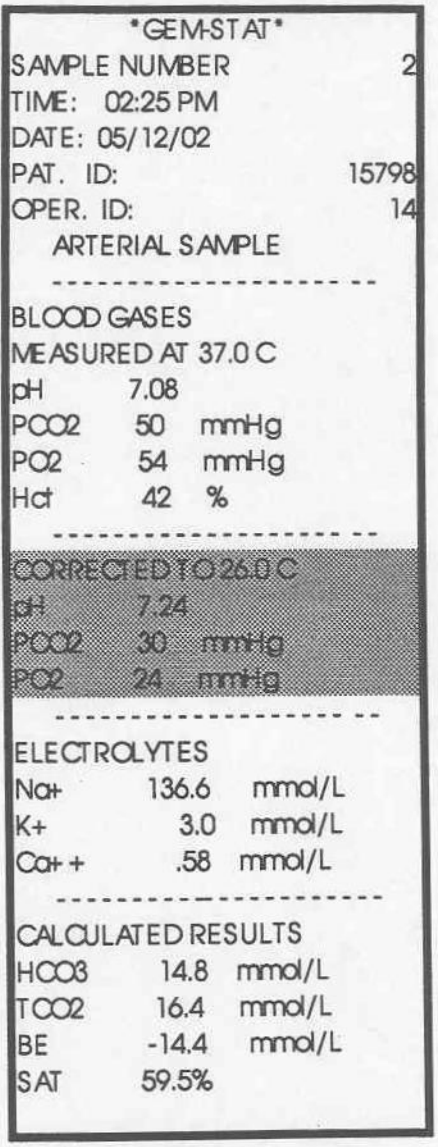
Printed on most reports.

STANDBY mode

Printed on the STATUS report.

Temperature Correction.

When a blood sample temperature is corrected (by the user), a block of data is inserted in the report that contains the temperature-corrected gas values.



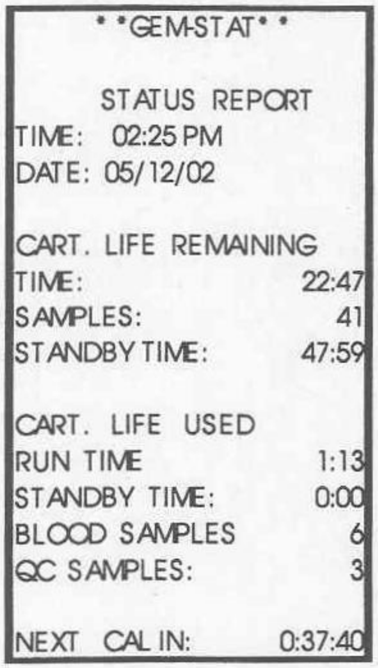
```
        *GEM-STAT*
SAMPLE NUMBER              2
TIME:  02:25 PM
DATE: 05/12/02
PAT. ID:               15798
OPER. ID:                 14
   ARTERIAL SAMPLE
   -------------------- --
BLOOD GASES
MEASURED AT 37.0 C
pH        7.08
PCO2       50   mmHg
PO2        54   mmHg
Hct        42   %
   -------------------- --
CORRECTED TO 26.0 C
pH         7.24
PCO2       30   mmHg
PO2        24   mmHg
   -------------------- --
ELECTROLYTES
Na+         136.6   mmol/L
K+            3.0   mmol/L
Ca++          .58   mmol/L
   ---------------------
CALCULATED RESULTS
HCO3        14.8   mmol/L
TCO2        16.4   mmol/L
BE         -14.4   mmol/L
SAT        59.5%
```

Temperature
Corrected to 26.0C

Fig. A5-5, Temperature Corrected Printout

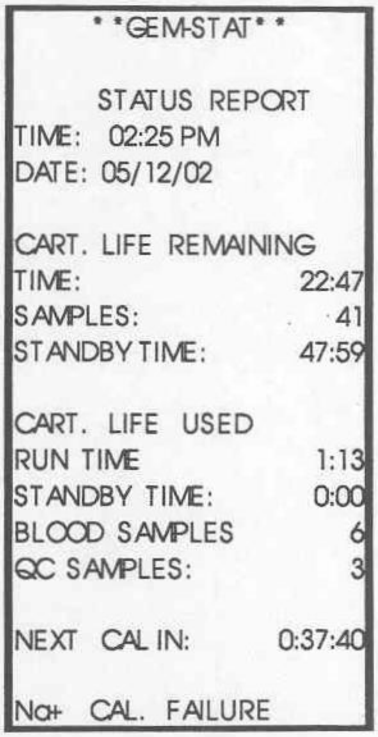
Cartridge STATUS Report

A report that lists time and tests done/remaining on a cartridge as well as current sensor status.



```
      **GEM-STAT**

     STATUS REPORT
TIME:  02:25 PM
DATE: 05/12/02

CART. LIFE REMAINING
TIME:                22:47
SAMPLES:                41
STANDBY TIME:        47:59

CART.  LIFE  USED
RUN TIME              1:13
STANDBY TIME:         0:00
BLOOD SAMPLES            6
QC SAMPLES:              3

NEXT  CAL IN:      0:37:40
```

(No sensor failures)



```
      **GEM-STAT**

     STATUS REPORT
TIME:  02:25 PM
DATE: 05/12/02

CART. LIFE REMAINING
TIME:                22:47
SAMPLES:                41
STANDBY TIME:        47:59

CART.  LIFE  USED
RUN TIME              1:13
STANDBY TIME:         0:00
BLOOD SAMPLES            6
QC SAMPLES:              3

NEXT  CAL IN:      0:37:40

Na+  CAL.  FAILURE
```

(Na+ sensor failure)

Fig. A5-6, Status Reports

RECORD KEEPING AND REPRINTS

QC and Calibration data records can be reprinted any time for a "live" cartridge as described in Section 3.4, "Record Keeping and Reprinting". These reports have the word, "REPRINT" printed on them.

APPENDIX 6; PRINTOUTS

** IMPORTANT NOTICE **

Which Model GEM Stat do you own?

Use this appendix ONLY if you are operating the Dual Voltage (120/230V) GEM Stat instrument. Substitute the pages in this appendix for the appropriate pages as listed below.

If you are operating the 120V, 60Hz instrument, this appendix is NOT applicable.

IF YOU ARE OPERATING THE DUAL VOLTAGE INSTRUMENT:

Discard page:	Replace with:
7-11	A6-2
7-13	A6-3
7-17	A6-4
7-18	A6-5
7-19	A6-6
7-20	A6-7
8-1	A6-8
8-8	A6-9
8-30	A6-10
8-31	A6-11 and A6-12
8-32	A6-13
8-33	A6-14
8-34	A6-15
8-35	A6-16

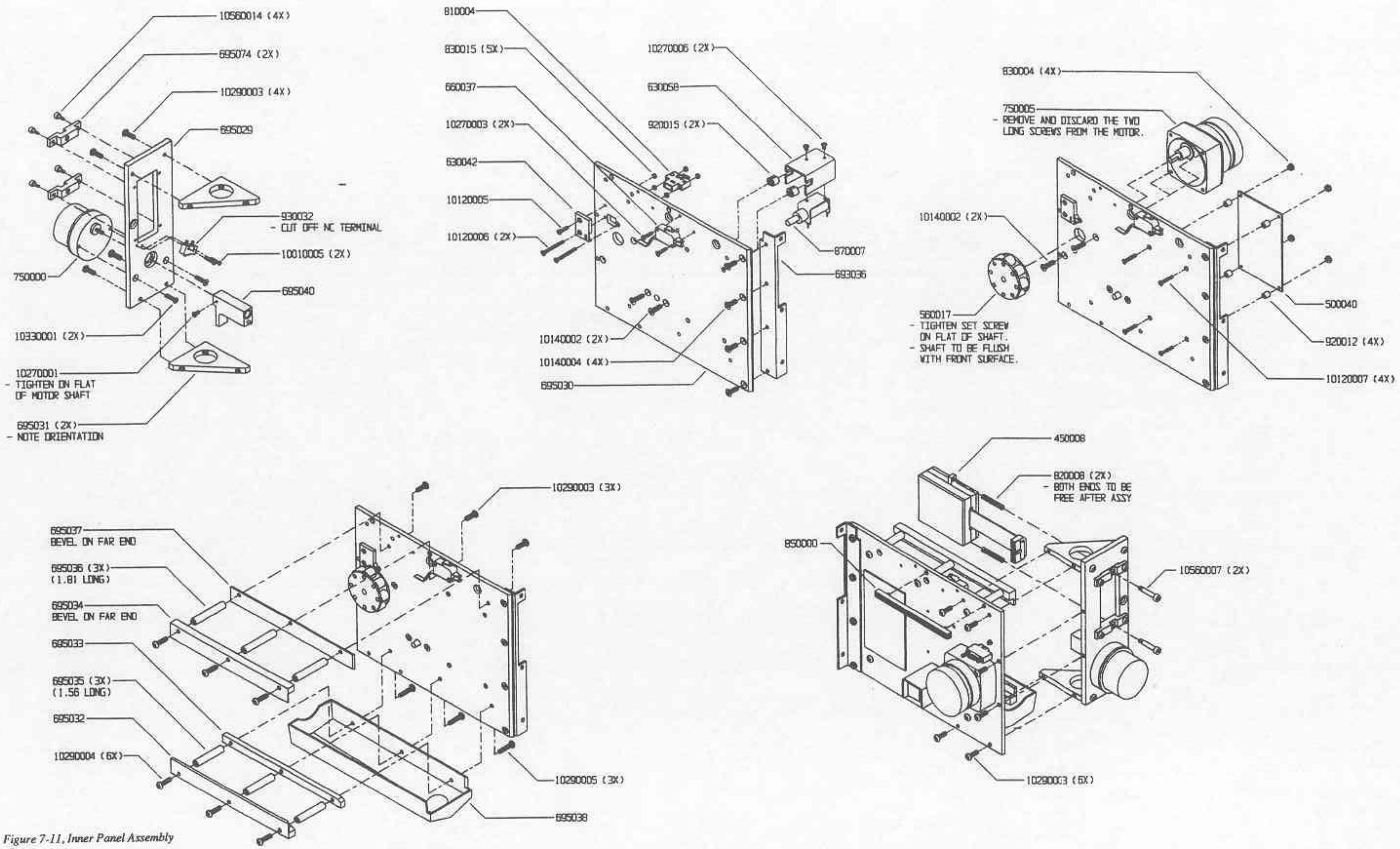

10560014 (4X)
695074 (2X)
10290003 (4X)
695029
930032
- CUT OFF NC TERMINAL
10010005 (2X)
750000
695040
10330001 (2X)
10270001
- TIGHTEN ON FLAT
OF MOTOR SHAFT
695031 (2X)
- NOTE ORIENTATION
810004
830015 (5X)
660037
10270003 (2X)
630042
10120005
10120006 (2X)
10270006 (2X)
630058
920015 (2X)
870007
693036
10140002 (2X)
10140004 (4X)
695030
830004 (4X)
750005
- REMOVE AND DISCARD THE TWO
LONG SCREWS FROM THE MOTOR.
10140002 (2X)
560017
- TIGHTEN SET SCREW
ON FLAT OF SHAFT.
- SHAFT TO BE FLUSH
WITH FRONT SURFACE.
500040
920012 (4X)
10120007 (4X)
10290003 (3X)
695037
BEVEL ON FAR END
695036 (3X)
(1.81 LONG)
695034
BEVEL ON FAR END
695033
695035 (3X)
(1.56 LONG)
695032
10290004 (6X)
10290005 (3X)
695038
450008
820008 (2X)
- BOTH ENDS TO BE
FREE AFTER ASSY
850000
10560007 (2X)
10290003 (6X)

Figure 7-11, Inner Panel Assembly

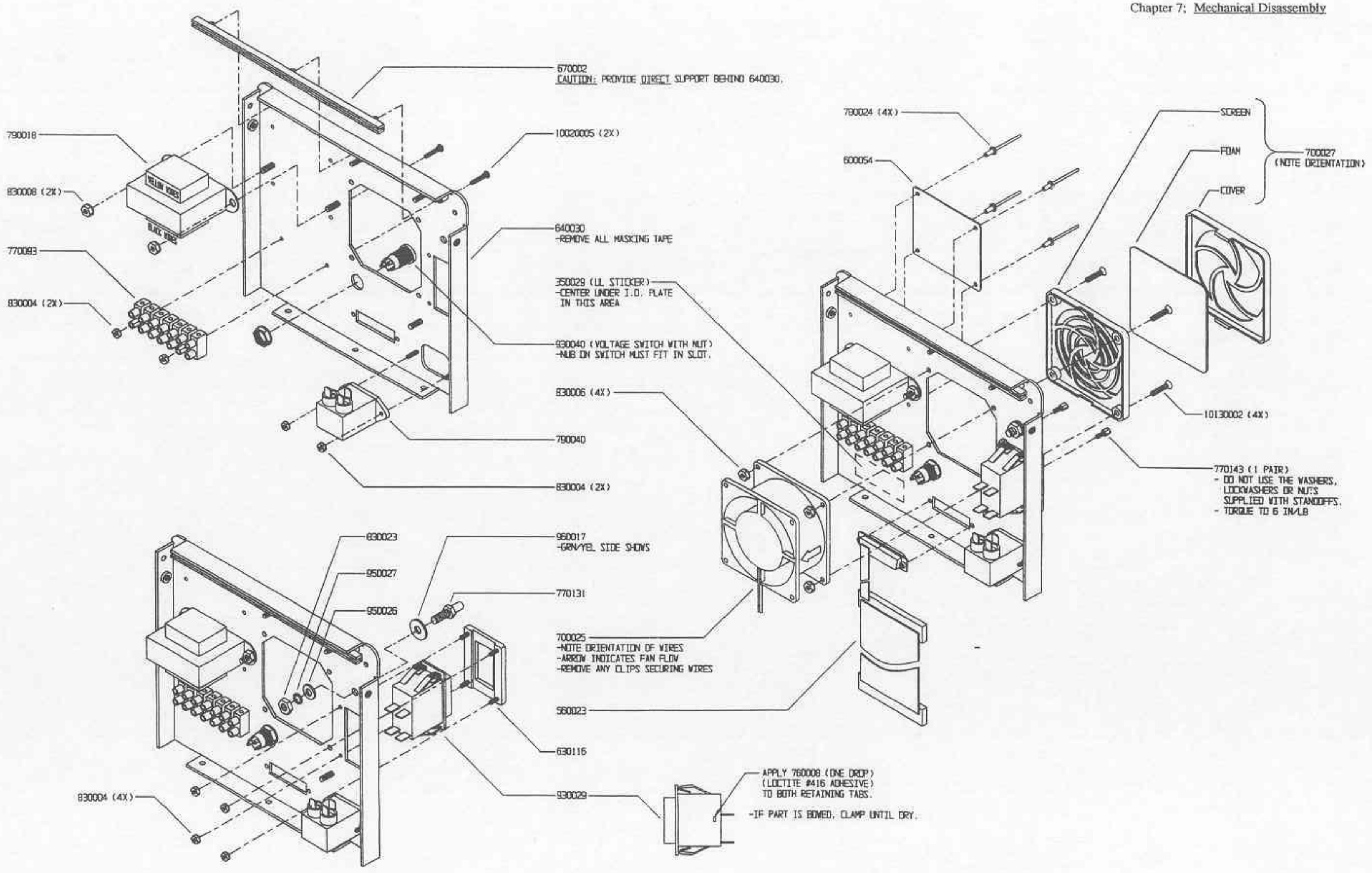

670002
CAUTION: PROVIDE DIRECT SUPPORT BEHIND 640030.
790018
830008 (2X)
770093
830004 (2X)
10020005 (2X)
640030
-REMOVE ALL MASKING TAPE
350029 (UL STICKER)
-CENTER UNDER I.D. PLATE
IN THIS AREA
930040 (VOLTAGE SWITCH WITH NUT)
-NUB ON SWITCH MUST FIT IN SLOT.
830006 (4X)
790040
830004 (2X)
YELLOW WIRES
BLACK WIRES
790024 (4X)
600054
SCREEN
FOAM
COVER
700027
(NOTE ORIENTATION)
10130002 (4X)
770143 (1 PAIR)
- DO NOT USE THE WASHERS,
LOCKWASHERS OR NUTS
SUPPLIED WITH STANDOFFS.
- TORQUE TO 6 IN/LB
830023
950027
950026
960017
-GRN/YEL SIDE SHOWS
770131
700025
-NOTE ORIENTATION OF WIRES
-ARROW INDICATES FAN FLOW
-REMOVE ANY CLIPS SECURING WIRES
560023
630116
930029
830004 (4X)
APPLY 760008 (ONE DROP)
(LOCTITE #416 ADHESIVE)
TO BOTH RETAINING TABS.
-IF PART IS BOWED, CLAMP UNTIL DRY.

Fig. 7-13, Rear Panel Assembly

7.5 COMPLETE GEM STAT PARTS LIST

MSS PART #	PART NAME, AND DESCRIPTION
10010001	Screw, 2-56x3/8, pan, head, black
10010003	Screw, 2-56x1/8, pan, slot, zinc
10010005	Screw, 2-56x1/2, pan, slot, black
10020005	Screw, 4-40x5/8, pan head, black
10120006	Screw, 4-40x1-1/4, flat, slot, zinc
10120007	Screw, 4-40x5/8, flat, phil, black
10130002	Screw, 6-32x5/8, flat, phil, black
10140001	Screw, 8-32x1/4, flat, phil, black
10140002	Screw, 8-32x1/2, flat, phil, black
10140004	Screw, 8-32x3/8, pan head, black
10270001	Screw, 4-40x1/4, button hd, black
10270003	Screw, 4-40x1/2, hd black
10270006	Screw, 4-40x3/16, button, hd, soc
10280001	Screw, 6-32x1/4, button, hd, soc
10280003	Screw, 6-32x1/2, button, hd, black
10290001	Screw, 8-32x3/8, button hd, black
10290002	Screw, 8-32x1/4, button, hd, black
10290003	Screw, 8-32x1/2, buttonn, hd, black
10290004	Screw, 8-32x5/8, button, hd, black
10290005	Screw, 8-32x3/4, button, hd,.black
10290007	Screw, 8-32x5/16, button, hd, soc, black
10300001	Screw, 10-32x3/8, button, hd, black
10330001	Screw, 6-56x1/2, flat, soc, black
10560004	Screw, 3mm x 5mm, flat, hd, slot
10560007	Screw, 8-32, soc, hd, shoulder, ss
10560014	Screw, 4-40, soc, hd, shoulder, ss
10650006	Screw, 1/4-20x1/2, soc, hd.
450008	Heater block/buffer Amplifier Assy.
450014	Subassy, front panel locking,
450015	Subassy, locking inner wall, GEM Stat
480006	A/D board assy, GEM Stat
500018	AC power board, GEM Stat & GEM6
500025	Solenoid driver PC board
550007	Main transformer, xfmr-1
550022	Subassy, Rear Panel, GEM Stat
550024	Subassy, Cart. Door, locking GEM Stat
560003	Subassy, Printer, GEM Stat & GEM6
560004	Printer Interface Cable, (30 pin)
560016	Printer Power Cable (4 pin)
560017	Pump Roller Assy
560019	Photo Sensor Cable
560022	Subassy, cover, GEM Stat
560023	Main Harness, ribbon cable

MSS PART #	PART NAME, AND DESCRIPTION
560027	Solenoid Driver Cable
560030	Ground Strap
590014	Paper Door Weldment, GEM Stat
600054	Serial Number Plate
610005	Membrane switch, GEM Stat
630005	Axis, door spring
630019	Bracket, mtg, line filter,
630031	Shell, printer
630040	Semi-hat
630042	Sight limiter, photo sensor
630050	Cartridge door hinge
630051	Door, paper GEM Stat
630052	Hinge, paper door
630053	Cage of door spring (new)
630054	Slide holder, interlock
630055	Door stop, interlock
630056	Slide interlock
630057	Gadget bracket, interlock
630058	Solenoid brkt (k2), interlock
630059	Cartridge door, GEM Stat
630060	Front panel, GEM Stat
630061	Cap, printer
640013	Rear Panel, GEM Stat universal
650004	Left-hand Guide Rail
650005	Right-hand Guide Rail
650006	Chassis, bottom plate
650011	Cover, GEM Stat
660026	Faster, magnet, fabricated
660037	Cartridge Enable Switch (SW1)
660038	Latch assy.
670002	Trimmed card guide
670002	Trimmed card guide
693036	Iron angle
693066	Tear off strip
693067	Tension bracket, spring
693076	Perforated "I" plate
693092	Skid plate, printer
695013	Standoff, nylon/delrin
695029	Inner wall, narrow
695030	Inner wall, long
695031	Holder of perpendicular
695032	Rail, lower left
695033	Rail, lower right
695034	Rail, high left

MSS PART #	PART NAME, AND DESCRIPTION
695035	Spacer, low, 1.56 long
695036	Spacer, high, 1.81 long
695037	Rail, high right
695038	Gutter
695040	Valve Control Arm
695046	Printer, paper spindle
695056	Insulator, printer
695058	A/D Board Insulator
695074	Insulator, bottom (Heater block)
700025	Fan, 3 1/8
700027	Fan guard, Filter retainer, filter media for fan
730001	Foot, rubber
730007	Cap, plastic, blk
750000	Valve motor
750005	Pump motor
760003	Teflon tape, 1" wide
760023	Tubing, heat shrink, 3/16 id, blk
770093	Terminal block (7 position)
770131	Plug, grounding "euro"
770143	Jack/Socket Assy, Short
770148	Faston tab, .250 series
780020	Retaining ring, external 3/8, SS
780021	Retaining ring, external 3/8, ss
780024	Pop rivet. 1/8 dia., Al
790018	Transformer, Isolated, xfmr-2
790040	Connector, primary power
810004	Photo micro sensor
820001	Spring, torsion, ss
820008	Spring, compression
830004	Keps nut, 4-40
830006	Keps nut, 6-32
830008	Keps nut, 8-32
830010	Keps nut, 10-32
830012	Hex nut, #2-56
830015	Hex nut, 4-4-, 3/16 across flats
830023	Nut, 0.8 d/mg "euro"
850000	A/D Board card guide, 4 1/2"
850001	A/D Board card guide, 6"
870006	Door Lock Solenoid (k1), 24v, 10%, ms-6
870007	Cartridge Enable Solenoid (k2), inner wall, 24v,
880001	Diode, IN4003
91001007	Capacitor, Mp, 250vdc, 0.1mfd
920009	Sheet edge fastener
920011	Stand-off, printer PC board

MSS PART #	PART NAME, AND DESCRIPTION
920012	Stand-off, insulator
920012	Stand-off, insulator
920015	Sheet edge fastener, 8-32, white
920017	Stand-off, .115 id x 3/16" long
930029	Power switch/circuit breaker 1.5a
930032	Home switch (SW2)
930034	Door Lock Switch (SW3), 0.1amp.,125v,
930040	Line Voltage Selector Switch (VSS1)
940010	Cable tie, 3.9" long, mini
940014	Mount, cable tie
940041	Ribbon cable clamp
950001	Flat washer, nylon #8
950002	Flat washer, #2, ss
950004	Lock washer, 4-40
950005	Flat washer, #4
950011	Flat washer, #10
950018	Flat washer, nylon, #4
950023	Lock washer, internal, #2, ss
950026	Flat washer, m6 "euro"
950027	Washer, external-tooth lock m6
950028	Lock washer, #10 internal tooth
960013	Varister, 130 VAC, 38 joules
960017	Color marking disk, "euro"

CHAPTER 8; ELECTRICAL CIRCUITS

8.1 POWER SUPPLY

The GEM Stat Power Supply consists of the Power Supply Assembly (Part #500041); Main transformer (#550007) and Isolation transformer (#790018); and some parts on the A/D Board assembly (#500027).

Primary Power (Ref. fig 8-17)

Power enters the primary power connector/line filter (PFL1) and is passed along to the circuit breaker/switch (CB1), then the power transformer (XFMR1), the isolated side of transformer (XFMR2), fan (FAN1), capacitor (CB1), Transorbs (Z1, Z2) and the voltage selector switch (VSS1). Full line voltage is applied to the capacitor when the circuit breaker/switch is closed. When the voltage selector switch is set to 115VAC, the two 120 VAC windings on XFMR1 are in parallel with each other and the fan, the isolated side transformer (XFMR2), and the two Transorbs. When switched to 230VAC, the two 120 VAC windings on transformer XFMR1 are placed in series with each other, each winding its own 130VAC transorb across it. Each 120VAC winding has either the fan or the isolated side transformer across it, supplying 120VAC to these devices.

Isolated Power Supply

The Isolated Power Supply provides power to the analog circuitry of the Heater Block Amplifier and A/D Board. All circuitry that is powered by this isolated supply is optically isolated from the CPU and other components powered by the Main Power Supply. The isolated power is supplied by the Isolation Transformer and Isolation regulator circuitry located on the A/D Board. P7 receives approximately 21 VAC from the secondary of the isolated power transformer located on the rear panel. Positive half-wave rectification and filtering is performed by D11 and C34, and negative rectification and filtering is performed by D12 and C36. VR1 is a standard 7815 type regulator and supplies regulated (+) 15VDC. VR2 supplies regulated(-) 15VDC. VR3 is a precision shunt regulator which supplies 2.500 VDC reference voltage. RV2 is used to trim this voltage. 21VAC from P7 is also applied to K1, a solid State relay. K1 cycles power on and off, under microprocessor control, to the heater in the heater block.

Main Power Supply

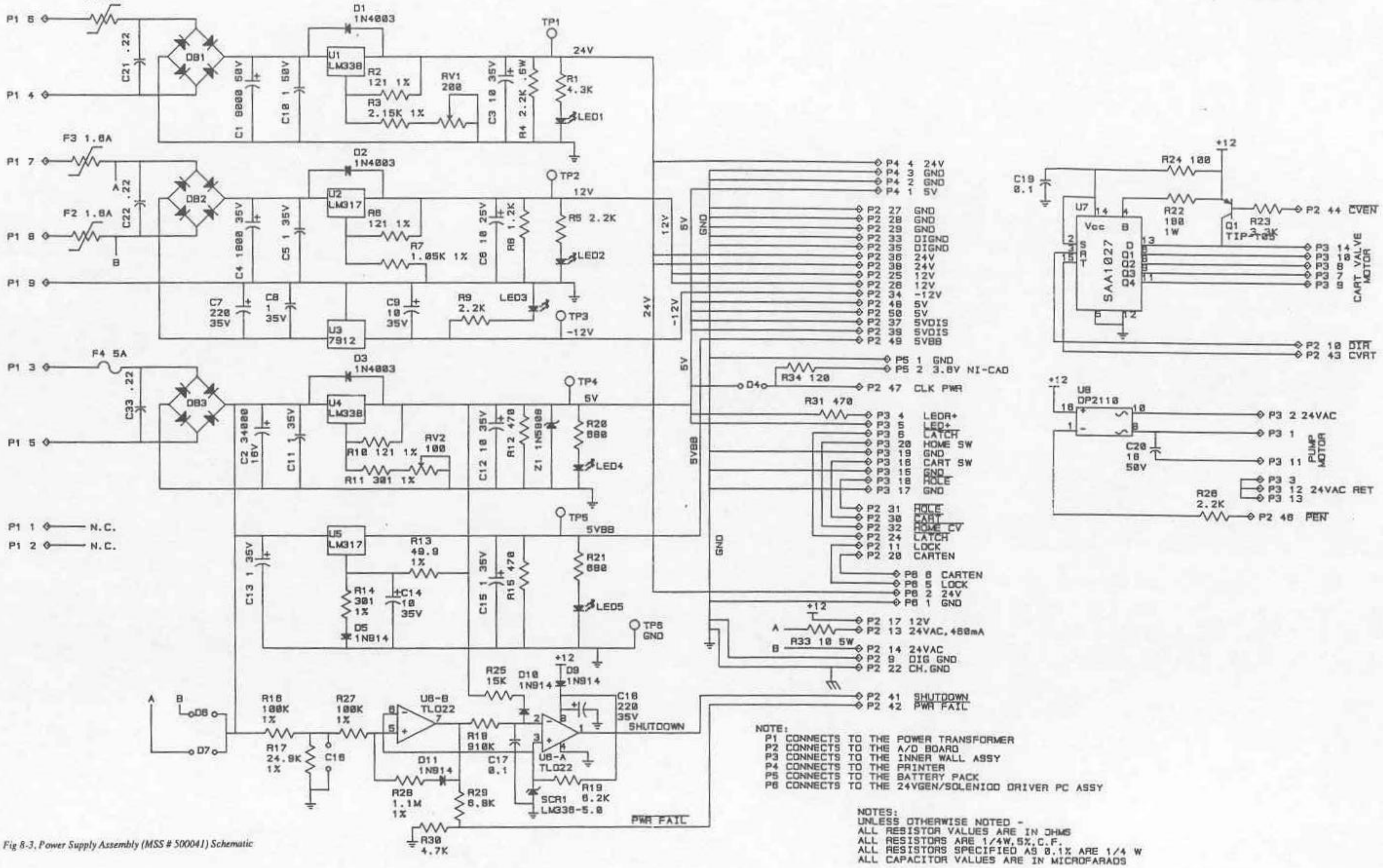
The main supply provides regulated DC and AC voltages to the digital part of the A/D Board Assembly, the printer, motors and solenoids, and is divided as follows:

- D.C. Power Supply
- Power Fail Detect Circuit
- Motor Control
- Signal Interconnection

DC Power Supply (500018 Power Supply Assembly)
The D.C. Power Supply and the Main Transformer (#550007) are both mounted on the chassis of the GEM Stat Instrument just forward of the rear panel.

The Main Power Supply provides the following voltages:

- 24 VDC @ 750 mA
- 12 VDC @ 400 mA
- 5.6 VDC @ 50 mA
- -12 VDC @ 100 mA
- 5 VDC @ 3 A


P1 6
F1 3A
C21 .22
DB1
P1 4
D1
1N4003
U1
LM338
C1 8000 50V
C10 1 50V
R2
121 1%
R3
2.15K 1%
RV1
200
TP1
24V
C3 10 35V
R4 2.2K .5W
R1
4.3K
LED1
P1 7
F3 1.6A
A
C22 .22
F2 1.6A
P1 8
B
DB2
D2
1N4003
U2
LM317
C4 1000 35V
C5 1 35V
R6
121 1%
R7
1.05K 1%
TP2
12V
C6 10 25V
R8 1.2K
R5 2.2K
LED2
P1 9
C7
220
35V
C8
1
35V
U3
7912
C9
10
35V
R9
2.2K
LED3
TP3
-12V
P1 3
F4 5A
C33 .22
DB3
P1 5
D3
1N4003
U4
LM338
C2 34000 16V
C11 1 35V
R10 121 1%
RV2
100
R11 301 1%
TP4
5V
C12 10 35V
R12 470
Z1 1N5808
R20
680
LED4
P1 1
N.C.
P1 2
N.C.
U5
LM317
C13 1 35V
R13
49.9
1%
R14
301
1%
C14
10
35V
D5
1N914
TP5
5VBB
C15 1 35V
R15 470
R21
680
LED5
TP6
GND
A
B
D6
D7
R16
100K
1%
R17
24.9K
1%
C16
R27
100K
1%
U6-B
TL022
R18
910K
D11
1N914
R28
1.1M
1%
R29
6.8K
R30
4.7K
C17
0.1
R25
15K
D10
1N914
+12
D9
1N914
U6-A
TL022
C18
220
35V
SHUTDOWN
SCR1
LM336-5.0
R19
6.2K
PWR FAIL
24V
12V
5V
GND
-12V
5V
5VBB
GND
P4 4 24V
P4 3 GND
P4 2 GND
P4 1 5V
P2 27 GND
P2 28 GND
P2 29 GND
P2 33 DIGND
P2 35 DIGND
P2 36 24V
P2 38 24V
P2 25 12V
P2 26 12V
P2 34 -12V
P2 48 5V
P2 50 5V
P2 37 5VDIS
P2 39 5VDIS
P2 49 5VBB
P5 1 GND
P5 2 3.6V NI-CAD
D4
R34 120
P2 47 CLK PWR
R31 470
P3 4 LEDR+
P3 5 LED+
P3 6 LATCH
P3 20 HOME SW
P3 19 GND
P3 16 CART SW
P3 15 GND
P3 18 HOLE
P3 17 GND
P2 31 HOLE
P2 30 CART
P2 32 HOME CV
P2 24 LATCH
P2 11 LOCK
P2 20 CARTEN
P6 6 CARTEN
P6 5 LOCK
P6 2 24V
P6 1 GND
+12
P2 17 12V
A
P2 13 24VAC, 460mA
R33 10 5W
B
P2 14 24VAC
P2 9 DIG GND
P2 22 CH.GND
P2 41 SHUTDOWN
P2 42 PWR FAIL
C19
0.1
+12
R24 100
U7
Vcc
B
S
R
T
D
Q1
Q2
Q3
Q4
SAA1027
R22
100
1W
Q1
TIP-105
R23
3.3K
P2 44 CVEN
P3 14
P3 10
P3 8
P3 7
P3 9
CART VALVE
MOTOR
P2 10 DIR
P2 43 CVRT
+12
U8
DP2110
C20
10
50V
P3 2 24VAC
P3 1
P3 11
PUMP
MOTOR
P3 3
P3 12 24VAC RET
P3 13
R26
2.2K
P2 46 PEN

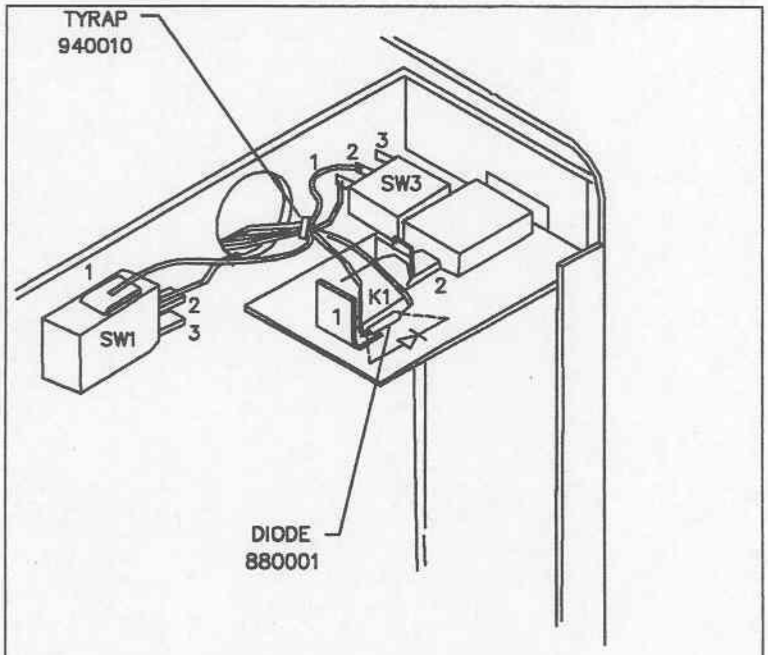
NOTE:
P1 CONNECTS TO THE POWER TRANSFORMER
P2 CONNECTS TO THE A/D BOARD
P3 CONNECTS TO THE INNER WALL ASSY
P4 CONNECTS TO THE PRINTER
P5 CONNECTS TO THE BATTERY PACK
P6 CONNECTS TO THE 24VGEN/SOLENIOD DRIVER PC ASSY

NOTES:
UNLESS OTHERWISE NOTED -
ALL RESISTOR VALUES ARE IN OHMS
ALL RESISTORS ARE 1/4W,5%,C.F.
ALL RESISTORS SPECIFIED AS 0.1% ARE 1/4 W
ALL CAPACITOR VALUES ARE IN MICROFARADS

Fig 8-3, Power Supply Assembly (MSS # 500041) Schematic the system goes to "INSERT CART", (K2) is energized and pulls in the plunger in allowing a cartridge to be inserted.

Transistor Q1 on the Solenoid Driver Board controls the Cartridge Enable solenoid (K2), and is driven by the "CARTEN" signal at P1-6, J6-6. Transistor Q2 drives the Door Lock solenoid (K1), and is driven by the "LOCK" signal at P1-5, J6-5. Both solenoids are powered by (+) 24VDC, at P1-2, from the power supply. The signals "CARTEN" and "LOCK" come from U27 on the A/D Board.

Crystal X1 and counter U1 generate a 60 Hz square wave. This signal controls the H-bridge driver, U2. The output of U2 is two 24VDC square waves at U2-2 and U2-10, exactly 180 degrees out of phase with each other. These signals are sent to the motor control relay (U8) on the power supply PC assembly.



WIRE LIST

FROM	TERM	WIRE COLOR	TERM	TO
INNERWALL SW1-1	——	BLK	SOLDER	SW3-1
INNERWALL	——	RED	SOLDER	SW3-2
INNERWALL	——	YEL	SOLDER	K1-1
D1 CATHODE	SOLDER DIODE 880001 D1 BETWEEN K1-1 & K1-2			D1 ANODE
K1-2	SOLDER	GRN	——	INNERWALL

Fig. 8-11, SW1, SW3 and K1 Wiring Diagram

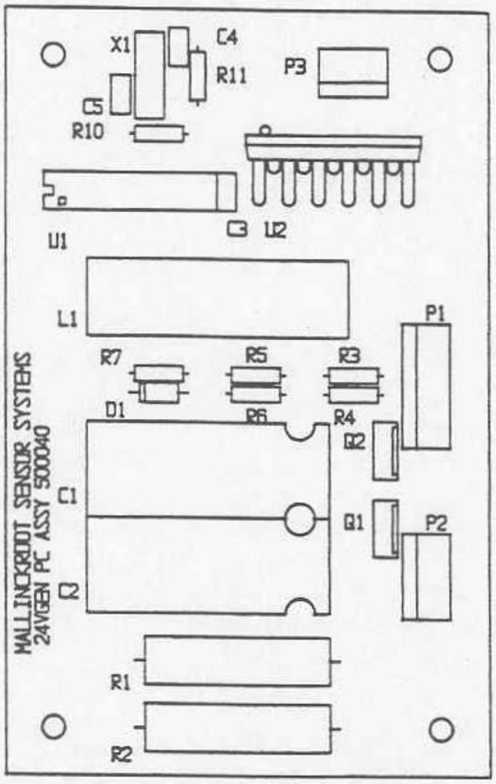
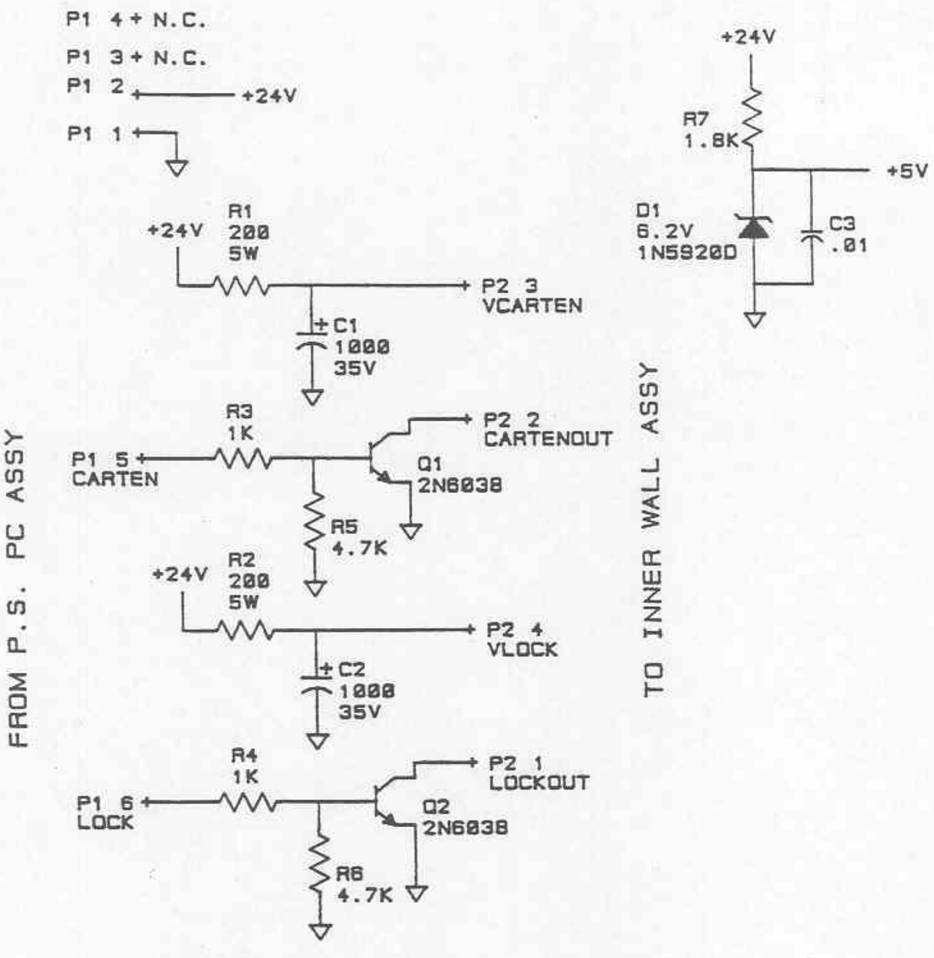

X1
C4
R11
P3
C5
R10
U1
C3
U2
L1
P1
R7
R5
R3
D1
R6
R4
Q2
C1
Q1
P2
C2
R1
R2
MALLINCKRODT SENSOR SYSTEMS
24VGEN PC ASSY 500040

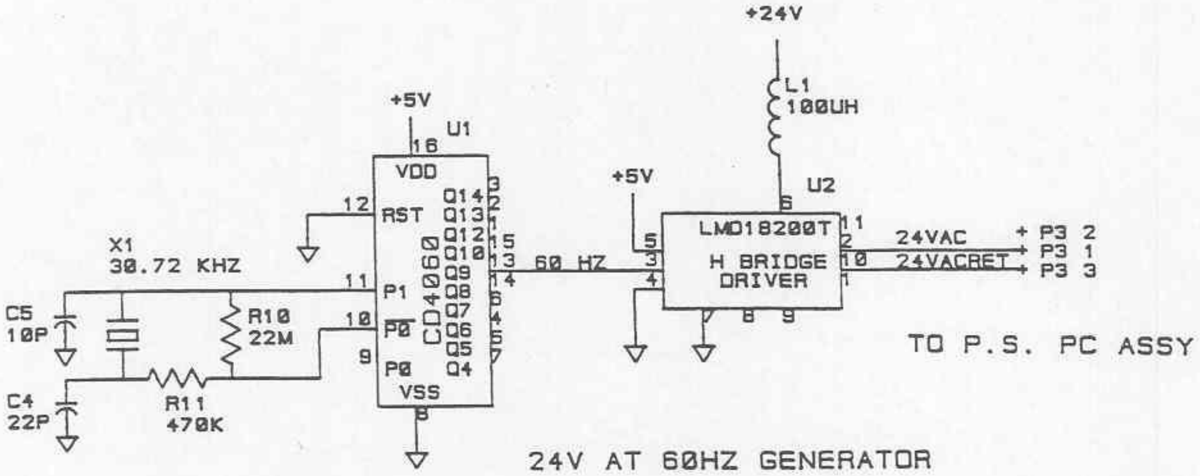
Fig. 8-12, Solenoid Driver PCB layout

Parts List for Solenoid Driver Board

QTY	MSS PART #	LOCATION	DESCRIPTION
1	600055		PCB, 24VGEN
2	31052200	R1, R2	RESISTOR,WW,5W,5%, 200 OHM
2	34453100	R3, R4	RESISTOR, CARB COMP., 1/4W, 5%, 1 K
1	34453180	R7	RESISTOR, 1/4W, 5%, 1.8K
2	34453470	R5, R6	RESISTOR, 1/4W, 5%, 4.7 K
1	34455470	R11	RESISTOR, 1/4W 5%, 470K
1	65502211	C4	CAPACITOR, 22pF, 50V, RADIAL, CERAMIC
1	65521008	C3	CAPACITOR, .01uF, 50V, RADIAL, CERAMIC
1	65531011	C5	CAPACITOR, 10pF, 50V, RADIAL, CERAMIC
1	770047	P2	HEADER, SIL, 4 PIN, LOCKING
1	770135	P1	HEADER, SIL, 6 PIN, LOCKING
1	770193	P3	HEADER, SIL, 3 PIN, LOCKING
1	790038	L1	CHOKE, 100uH
2	80351003	C1, C2	CAP., 35V, 1000 MF, ELECT.
1	880018	D1	DIODE, ZENER, 6.2V, 1%, IN5920D
2	884011	Q1, Q2	TRANSISTOR,NPN, 2N6038
1	888036	U2	IC, H-BRIDGE DRIVER, LMD18200T
1	890041	U1	IC, CMOS, CD4060
1	910009	X1	CRYSTAL, 30.720 MHZ


P1 4 N.C.
P1 3 N.C.
P1 2
+24V
P1 1
+24V
R7
1.8K
+5V
D1
6.2V
1N5920D
C3
.01
+24V
R1
200
5W
P2 3
VCARTEN
C1
1000
35V
FROM P.S. PC ASSY
TO INNER WALL ASSY
R3
1K
P2 2
CARTENOUT
P1 5
CARTEN
Q1
2N6038
R5
4.7K
+24V
R2
200
5W
P2 4
VLOCK
C2
1000
35V
R4
1K
P2 1
LOCKOUT
P1 6
LOCK
Q2
2N6038
R6
4.7K

SOLENIOD DRIVER


+24V
L1
100UH
+5V
U1
16
VDD
+5V
U2
6
12
RST
Q14
Q13
Q12
Q10
Q9
Q8
Q7
Q6
Q5
Q4
3
2
1
15
13
14
6
4
5
7
CD4060
X1
30.72 KHZ
11
P1
10
P0
9
P0
VSS
8
60 HZ
5
3
4
LMD18200T
H BRIDGE
DRIVER
11
2
10
1
7
8
9
24VAC
24VACRET
P3 2
P3 1
P3 3
TO P.S. PC ASSY
C5
10P
R10
22M
C4
22P
R11
470K

24V AT 60HZ GENERATOR

Fig. 8-13, Solenoid Driver Board Schematic

8.7 INNER WALL ELECTRONIC CIRCUITRY

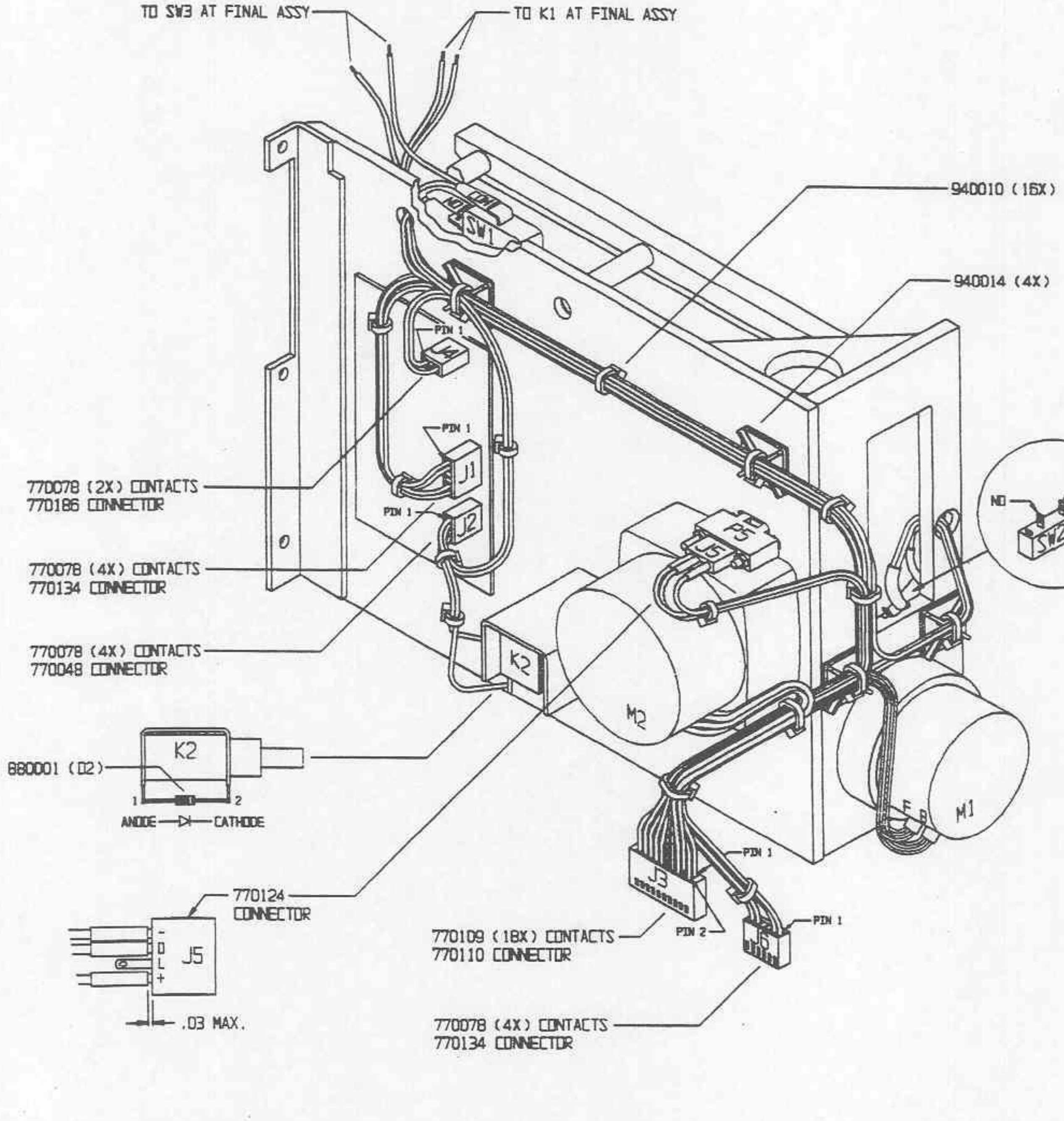

TO SW3 AT FINAL ASSY
TO K1 AT FINAL ASSY
COM
NO
SW1
940010 (16X)
940014 (4X)
PIN 1
J4
PIN 1
J1
PIN 1
J2
770078 (2X) CONTACTS
770186 CONNECTOR
770078 (4X) CONTACTS
770134 CONNECTOR
770078 (4X) CONTACTS
770048 CONNECTOR
NO
COM
SW2
P5
J5
K2
M2
M1
F
R
K2
880001 (D2)
1
2
ANODE
CATHODE
770124
CONNECTOR
-
D
L
+
J5
.03 MAX.
PIN 1
J3
PIN 2
PIN 1
J6
770109 (18X) CONTACTS
770110 CONNECTOR
770078 (4X) CONTACTS
770134 CONNECTOR

Fig. 8-14, Inner Wall Wiring Diagram

WIRE LIST

ITEM	FROM	TERM	STRIP	WIRE #	AWG	COLOR	LENGTH	STRIP	TERM	TO	FROM	TERM	STRIP	WIRE #	AWG	COLOR	LENGTH	STRIP	TERM	TO
1	M2	—	—	—	–	RED	6.50	.38	—	[4]		—	.38	940007	24	RED	1.38	.12	770109	J3-1
2						BLU	6.50	.38	—	[4]		—	.38	940002	24	BLU	1.38	.12	770109	J3-12
3						BLU	6.50	.38	—	[4]		—	.38	940002	24	BLU	1.38	.12	770109	J3-13
4						BLK	6.50	.38	—	[4]		—	.38	940001	24	BLK	1.38	.12	770109	J3-11
5	M1	FRONT	—	—	–	RED	5.00	.38	—	[4]		—	.38	940001	24	BLK	1.38	.12	770108	J3-14
6						BLK	5.00	.38												
7		BACK				RED	5.00	.38												
8						BLK	5.00	.38												
9		FRONT				YEL	6.00	.12	770109	J3-7										
10						GRY	6.00	.12	770109	J3-9										
11		BACK				YEL	6.00	.12	770109	J3-10										
12						GRY	6.00	.12	770109	J3-8										
13	SW2-NO	[2]	.25	940001	24	BLK	8.25	.12	770109	J3-19										
14			.25	940001	24	BLK	18.25	.25	[1]	SW1-COM										
15	SW3-COM	[3]	.25	940001	24	BLK	3.00	.25												
16	SW3-NO	[3]	.25	940007	24	RED	16.00	.12	770109	J3-6										
17	SW1-NO	[1]	.19	940008	24	WHT	15.75	.12	770109	J3-16										
18	SW2-COM	[2]	.19	940003	24	BRN	8.25	.12	770109	J3-20										
19	J5-(+)	[5]	.12	940007	24	RED	9.00	.12	770109	J3-5										
20	J5-D	[5]	.12	940009	24	YEL	9.00	.12	770109	J3-18										
21	J5-(-)	[5]	.12	940001	24	BLK	9.00	.12	770109	J3-17										
22	J2-1	770078	.12	940004	24	GRY	6.00	.25	SOLDER	K2-1										
23	K2-2	SOLDER	DIODE (D2)						SOLDER											
24		SOLDER	.25	940006	24	ORG	6.00	.12	770078	J2-3										
25	J2-2	770078	.12	940009	24	YEL	10.50	.25	[3]	K1-1										
26	J2-4	770078	.12	940005	24	GRN	10.50	.25	[3]	K1-2										
27	J1-1	770078	.12	940003	24	BRN	21.00	.12	770078	J6-1										
28	J1-2	770078	.12	940007	24	RED	21.00	.12	770078	J6-2										
29	J1-5	770078	.12	940005	24	GRN	21.00	.12	770078	J6-5										
30	J1-6	770078	.12	940002	24	BLU	21.00	.12	770078	J6-6										
31	J4-1	770078	.12	940003	24	BRN	17.00	.12	770109	J3-2										
32	J4-3	770078	.12	940006	24	ORG	17.00	.12	770109	J3-3										

NOTES:
- [1] SOLDER WIRE TO SWITCH, COVER SOLDERED JOINT WITH 760041 (HEATSHRINK) .75 LONG.
- [2] SOLDER WIRE TO SWITCH, COVER SOLDERED JOINT WITH 760037 (HEATSHRINK) .75 LONG.
- [3] TIN WIRE ONLY (WIRE WILL BE SOLDERED AT FINAL ASSEMBLY).
- [4] SPLICE WIRES TOGETHER, COVER SPLICE WITH 760037 (HEATSHRINK) .75 LONG.
- [5] SOLDER WIRE TO TAB, COVER SOLDERED JOINT WITH 760018 (HEATSHRINK) .38 LONG.

TOOL LIST

TERM	MFG	P/N	SETTING
770078	MOLEX	HTR 2262A	A
770109	AMP	90202-2	1

SCHEMATIC

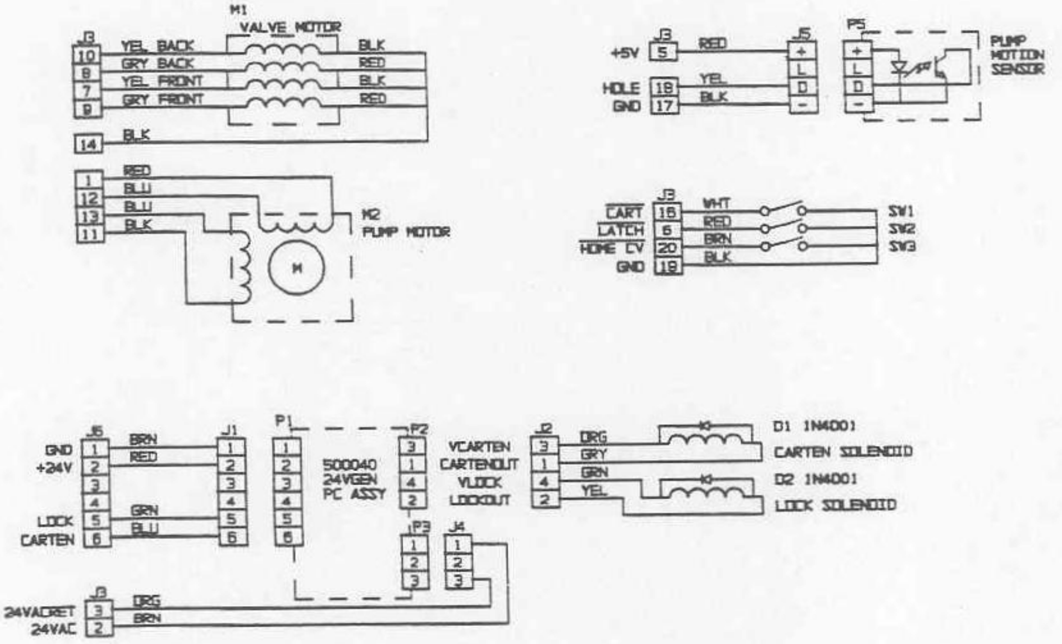

M1
VALVE MOTOR
J3
10
8
7
9
YEL BACK
GRY BACK
YEL FRONT
GRY FRONT
BLK
RED
BLK
RED
14
BLK
1
12
13
11
RED
BLU
BLU
BLK
M2
PUMP MOTOR
M
J3
+5V
5
RED
HOLE
18
YEL
GND
17
BLK
J5
P5
+
L
D
-
PUMP
MOTION
SENSOR
J3
CART
16
WHT
LATCH
6
RED
HOME CV
20
BRN
GND
19
BLK
SW1
SW2
SW3
J6
GND
+24V
LOCK
CARTEN
1
2
3
4
5
6
BRN
RED
GRN
BLU
J1
P1
P2
500040
24VGEN
PC ASSY
VCARTEN
CARTENOUT
VLOCK
LOCKOUT
J2
ORG
GRY
GRN
YEL
D1 1N4001
CARTEN SOLENOID
D2 1N4001
LOCK SOLENOID
P3
J4
J3
24VACRET
24VAC
3
2
ORG
BRN

Fig 8-15, Inner Wall Schematic

8.8 REAR PANEL ELECTRICAL CIRCUITRY

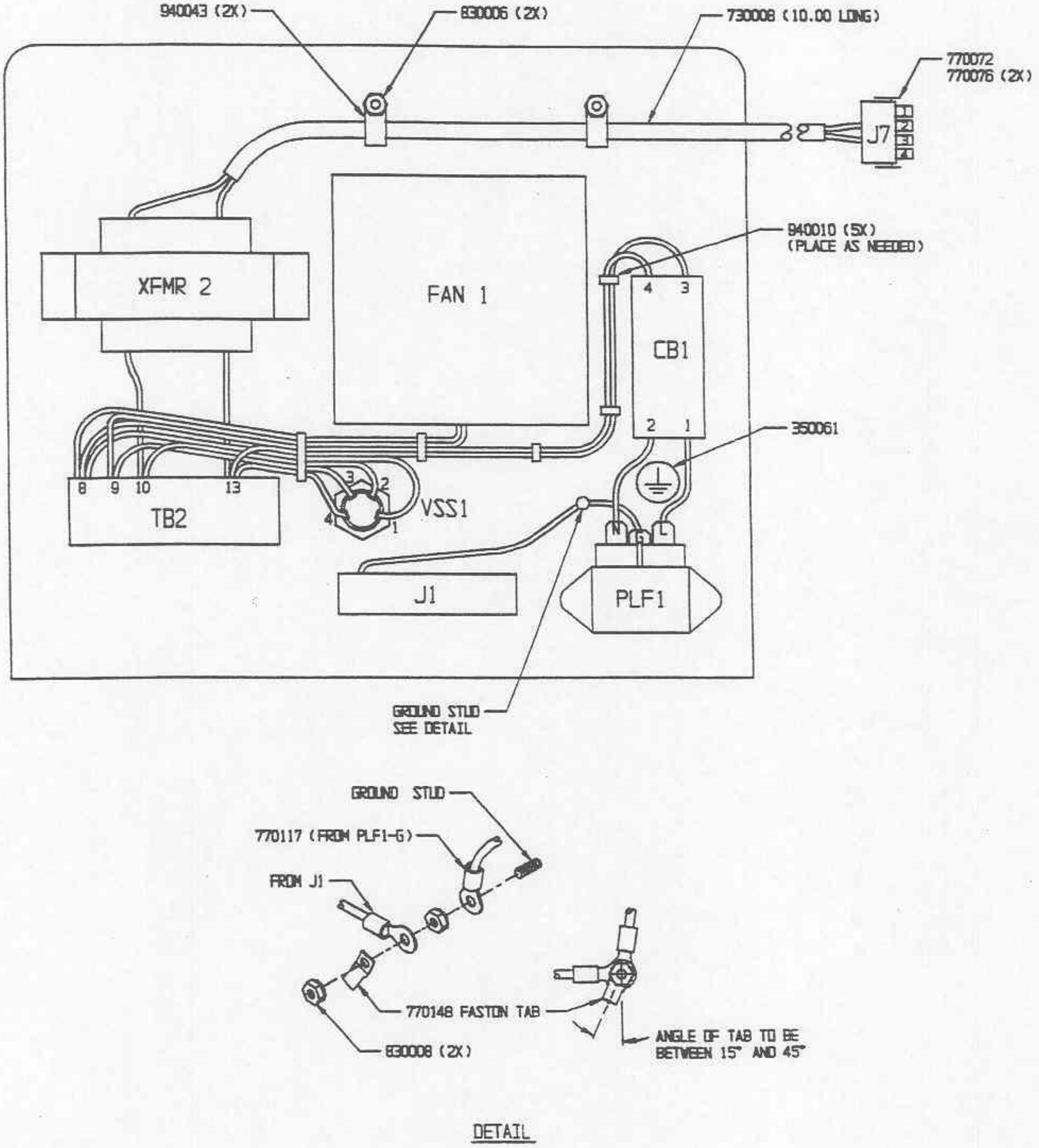

940043 (2X)
830006 (2X)
730008 (10.00 LONG)
770072
770076 (2X)
J7
1
2
3
4
940010 (5X)
(PLACE AS NEEDED)
XFMR 2
FAN 1
4
3
CB1
2
1
350061
8
9
10
13
TB2
3
2
4
1
VSS1
N
G
L
J1
PLF1
GROUND STUD
SEE DETAIL
GROUND STUD
770117 (FROM PLF1-G)
FROM J1
770148 FASTON TAB
830008 (2X)
ANGLE OF TAB TO BE
BETWEEN 15° AND 45°
DETAIL

Fig. 8-16, Rear Panel Wiring Diagram

WIRE LIST

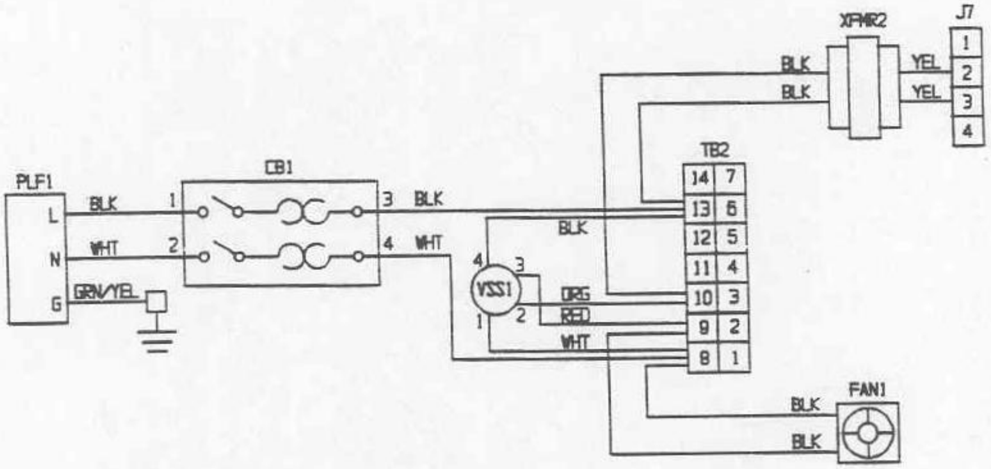
ITEM	FROM	TERM	STRIP	AWG	P/N	COLOR	LNG	STRIP	TERM	TO
1	TB2-8	——	.25	18	940030	WHT	6.00	.25	SOLDER ⚠	VSS1-1
2		——	.25	18	940030	WHT	11.00	.25	770125	CB1-4
3		——	.25	–	——	——	7.50	——	——	FAN1
4	TB2-9	——	.25	–	——	——	7.50	——	——	
5		——	.25	18	940051	RED	5.00	.25	SOLDER ⚠	VSS1-3
6	TB2-10	——	.25	18	940054	ORG	4.50	.25	SOLDER ⚠	VSS1-2
7		——	.25	–	——	BLK	2.50	——	——	XFMR2
8	J7-2	770076	.25	–	——	YEL	11.00	——	——	
9	J7-3	770076	.25	–	——	YEL	11.00	——	——	
10	TB2-13	——	.25	–	——	BLK	2.50	——	——	
11		——	.25	18	940028	BLK	9.50	.25	770125	CB1-3
12		——	.25	18	940028	BLK	4.00	.25	SOLDER ⚠	VSS1-4
13	PLF1-L	770125	.25	18	940028	BLK	3.00	.25	770125	CB1-1
14	PLF1-N	770125	.25	18	940030	WHT	3.00	.25	770125	CB1-2
15	PLF1-G	770125	.25	18	940029	GRN/YEL	2.00	.25	770117	GNDSTUD
16	J1	GROUND WIRE WITH RING TERMINAL								

} SEE DETAIL

⚠ INSTALL 760037 (SHRINK TUBING) OVER SOLDER JOINT, .50 LONG.

TOOL LIST

TERM	MFG	P/N	SETTING
770125	AMP	8547	–
770117	PALADIN	PA1601	–
770076	AMP	90300-1	1


XFMR2
J7
1
2
3
4
BLK
BLK
YEL
YEL
TB2
14 7
13 6
12 5
11 4
10 3
9 2
8 1
PLF1
L
N
G
BLK
WHT
GRN/YEL
CB1
1
2
3 BLK
4 WHT
BLK
4
3
VSS1
2
1
ORG
RED
WHT
FAN1
BLK
BLK

REAR PANEL SCHEMATIC

Fig 8-17, Rear Panel Schematic